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BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D. C.

DOCKET NO. 3929: An engineering conference on the problems arising in the allocation to services of radio frequencies above 30,000 kc., etc.

PRESENTATION FOR THE AMATEUR SERVICE

By the
AMERICAN RADIO
RELAY LEAGUE, INC.
West Hartford, Conn.

June, 1936

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By the

American Radio Relay League, Inc.,

West Hartford, Conn.

Kenneth B. Warner, General Manager
Francis E. Handy, Communications Manager
Ross A. Hull, Associate Editor, "QST"

Witnesses

Paul M. Segal
General Counsel

June, 1936

I - INTRODUCTION

Consideration of the service performed by amateur radio necessitates an understanding of its basic forms and of its background.

The growth and development of the institution of amateur radio parallels and in many respects correlates the development of the radio art as a whole. In the early years of radio communication many practitioners were amateur, from the standpoint that their experimental activities were not commercially sponsored. As success attended their experiments, and commercial adaptation resulted, these amateurs crossed the boundary and the basic amateur status was superseded by professionalism. Yet in many instances operation of an amateur type continued, with the result that to-day we are faced with the apparent anomaly of many professionals in radio also possessing an amateur status. The social and technological implications of this situation will be developed more fully in testimony to follow.

The true radio amateur as he exists to-day was derived partially from the class of youthful electrical experimenters and scientific novices of the late nineteenth century, and partially from the world of ordinary laymen who found an elemental psychological satisfaction in the practice of space communication without wires. There were a few of these amateurs before the turn of the century but they were insurmountably handicapped by lack of both apparatus and knowledge. During the first decade of the present century, however, both these requirements were slowly supplied, and numbers steadily grew.

For the first few years these neophytes were, in the main, solitary experimenters. Occasionally they used their apparatus for communication, but largely they were not even aware of each other's existence. Beginning in about the years 1906 to 1908, however, there transpired a basic change in the character of amateur radio. Apparatus and technique had improved sufficiently to enable communication over distances of a few miles. Acquaintances amongst experimenters in metropolitan areas occurred and multiplied. Beginning in 1909 radio clubs sprang up in many of the larger cities. These and other influences produced a gradual metamorphosis in the art, socializing the institution and placing increasing emphasis on communications aspects.

Increasing numbers and activity on the part of amateurs inevitably led to conflict with governmental and commercial services, a situation aggravated by the fact that in the early days many amateurs had superior equipment. By 1910 there were several thousand persons interested in amateur radio, most of them possessing transmitters, and interference between services became a serious problem. Numerous attempts at regulation through legislation were made. The first comprehensive federal radio law was not enacted until 1912, however. This law made due provision for private, or amateur, stations, but limited their operation to a frequency of 1500 kilocycles, the belief at that time being that frequencies of this order and higher were essentially worthless for long-distance communication.

Despite the unfavorable restriction, however, amateur radio continued. By the end of 1913 about 2000 amateur station licenses had been issued. In 1914 the national association, the American Radio Relay League, was formed. At the end of 1916 the number of licensed

stations exceeded 6000. The declaration of war in 1917 resulted in the closing down of these stations; simultaneously, amateur radio provided perhaps 4000 self-trained radio operators to the services, the nucleus for the most effective radio signal corps possessed by any of the combatant nations.

Returning to their barren 1500-kilocycle region following the war, amateurs adapted the fruits of compressed war-time research so successfully that they were at times able to span transcontinental and transoceanic distances with this frequency which had been discarded as worthless for long-distance work. It was not until a blend of over-congestion and individual inquisitiveness caused a few amateurs to investigate the theretofore almost unexplored frequencies above 1500 kilocycles that amateur radio entered its true domain. In 1923 the first two-way amateur communication across the Atlantic ocean was accomplished on 3000 kilocycles. By the end of 1924 the Antipodes had been linked by amateur high-frequency radio, and a year later amateurs all over the world were in communication with other amateurs in all continents on frequencies as high as 15 megacycles.

There could be no gesture more futile than to inform this Commission as to the value of the high-frequency region thus opened up to general exploration and use. Amateur radio, through its national organization, co-operated willingly in establishing an equitable and utilitarian sub-division of these high-frequency facilities amongst the various services, accepting for itself only small portions in the form of harmonically-related bands of relatively narrow width. Although adequate for their needs at that time, at the present time, due to subsequent curtailment by international treaty and greatly increased numbers, despite a program of intensified technical advance, the amateur bands are inadequate for the most effective carrying on of the amateur service.

The public services performed by amateur radio are of direct and great value to the national economy. Existing primarily as a giant communications system available for any special or emergency communications activity, these amateurs have developed an organized ability to contribute in many ways to public welfare. The extent and fundamental value of these services will be developed fully in testimony to follow.

In recent years, amateur radio, owing to the uniquely valuable characteristics afforded by its large numbers and diversification, has been largely responsible for the initial exploration of the ultra-high-frequency region. Amateurs were first to develop simple and reliable equipment for operation in the ultra-high-frequency region, first to occupy this territory in large numbers, and first to comprehensively record and evaluate its fundamental characteristics, which depart widely from those of the lower frequencies. It is to the interest of the entire radio art that adequate provision for amateurs be maintained in the frequency ranges at present under advisement, and that in the future space be continuingly afforded for amateur development beyond subsequently-established frontiers of useful government and commercial occupation.

II - THE ACCOMPLISHMENTS OF THE RADIO AMATEUR

The amateur has richly merited the policy of this nation of assigning him frequency bands of reasonable widths, and deserves a continuation of the same. It is possible to recite a large variety of benefits that the nation has received from the national policy of encouraging the practice of radio not for reasons of private or corporate gain but "solely with a personal aim and without pecuniary interest".

Amateur Radio is a Vast Training School

We would like first to emphasize the importance of amateur radio as the great training school for the radio art and industry. There is nothing quite like it in any other field of endeavor. Amateurs train and equip themselves at their own expense. They contribute vast resources of technical experimentation and emergency communication without cost to civilization. They constitute a mighty reservoir of self-trained operators available for the military in time of need. They provide the great source of self-trained engineering and operating and even executive personnel for the radio industry. The bulk of the familiar figures in the radio field to-day started as amateurs; a great many of them still operate amateur stations. The annual report of the Chief of the Radio Division of the Department of Commerce for the fiscal year ended June 30, 1928, reported the results of a survey made by the American Radio Relay League at the Division's request to determine the extent to which amateurs and former amateurs were occupied in the radio industry. Although figures on a group of the largest organizations were not available, it was found that of those engaged in executive positions in the radio industry, 45 presidents, 16 vice-presidents, 5 general managers, 69 managers, 37 owners, 324 engineers, 19 announcers and 11 directors were of amateur extraction. This list did not include operators. From another survey of approximately the same period it was found, of 9725 amateurs classified, that 1503 were engaged in radio engineering as a vocation. A total of 4917 were regularly doing service and repair work on radio receivers as a part- or whole-time vocation. Interviews with executives of radio broadcasting stations, radio manufacturing firms and radio communications systems demonstrate the high preponderance of amateur extraction. The operators and engineers of the largest broadcast station of the country are 100 per cent. licensed amateurs. This is true of many other stations; in the remainder, there is almost invariably a majority of licensed amateurs. We estimate that 85 or 90 per cent. of broadcast engineers and operators are amateurs. In the manufacturing field much the same is true. One large manufacturer has an almost entirely amateur-licensed engineering staff. Another employs amateurs exclusively in his test department, the critical point in the manufacturing process. Amongst commercial operators at shore stations and engineers of communications companies, amateur origins -- and, for that matter, present status -- are widely prevalent. In short, practically the entire personnel for the radio art and industry is derived from amateur radio.

Trained Operators for National Defense

Amateur radio is a vast reservoir of trained operators available for national defense in time of emergency. The communication needs of modern defense arms are prodigious. These skilled specialists cannot be trained over-night. In six months of strenuous training on the most likely candidates, only the most indifferent operators can be made out of plumbers and paper-hangers. Many thousands of radio amateurs have trained themselves

to a high degree of skill, actually by their own efforts and at their own expense, ready to serve the nation in time of peril. Several thousand of the best amateurs in the nation are enrolled in the Naval Communications Reserve, in grades running from Radioman Third Class to Lieutenant-Commander. They participate in weekly drills, over their own stations, and are ready to step into active service at an instant's notice. Through the Army-Amateur Radio System the Army maintains contact with some thousands of other amateurs who have been trained in the Army way of doing things. In time of war these men will naturally gravitate to the Army. It is reliably estimated that, of 6,000 amateurs in America before the war, perhaps 4,000 saw duty with the armed forces. The amateur is generally a young man and he is most ardently interested in his ability to communicate. With over 40,000 such individuals in the United States to-day, one of the most difficult problems of the military and naval services is virtually automatically solved.

Contributions to the Technique

The amateur's contributions to the technique of the radio art have been manifold. The amateur is an experimenter. He is generally not too much encumbered with ponderous knowledge. Not hesitating to tackle problems that he has not heard were insoluble, he frequently turns up with the answer. When the amateur was first banished to 1500 kc. and above by the Radio Act of 1912, the purpose was to accomplish his gradual extinction by his isolation on frequencies then regarded as worthless for useful communication. But he astonished the world by developing apparatus and methods to communicate at considerable distances on these despised frequencies. He was the first to demonstrate the value of the high frequencies, the first ever to tie the nations of the world together with high frequency and low power; before the amateur there was no occupancy of frequencies above 1500 kc.; the entire vast structure of high-frequency operation as it is known to-day, with a diversity of services embracing the world, has flowed exclusively from the pioneering developments and demonstrations of the radio amateur in 1923, and subsequently. Many specific technical developments can be mentioned. The first exposition of what was taking place in high-frequency sky-wave transmission was by an amateur. The first exposition and demonstration of the bending of ultra-high-frequency rays in the lower atmosphere was by an amateur. The most selective telegraph receiver in common use to-day, generally employed in amateur radio, is an amateur development. So is the startling arrangement recently given to a waiting world for the silencing of man-made electrical noises in radio receiving equipment. The items mentioned are only illustrative and are recent. Throughout the years the amateur has been a pioneer, working out the apparatus necessary for his peculiar problems in a fashion that the scientific and commercial branches of radio have followed with the greatest interest. One might refer, for example, to the amateur's magazine, "QST", in which the amateur's technical progress has been chronicled for many years, and refer to the fact that this journal is read in every important radio laboratory on the face of the earth, and that an impressive list of the most important developments in radio as we know it to-day first found publication in its pages.

Aids to Science and Research

The large number of amateurs, their scattered location over every portion of the nation and their diversification in talents, interests, abilities and choice of operating frequencies have made of this group an invaluable aid to science. Let something arise on which radio physicists need a large number of observations and almost instantly a very considerable group of skilled amateurs can be found who are interested in collaborating. Thus amateurs many years ago assisted the National Bureau of Standards in a comprehensive investigation into the fading of radio signals,

submitting many hundreds of charts in an organized series of tests run under the auspices of the Bureau. They have similarly participated in investigations into the effects of solar eclipses, in the Navy's early investigation of the skip effect in high-frequency transmission and, more recently, in the peculiar periodic daylight fade-outs of high frequencies noticed by the National Bureau of Standards. It need scarcely be emphasized that there exists no other medium of comparable extent or facilities for the making of large-scale observations along these lines. With amateurs existing in more than one hundred countries of the earth, with stations in practically every village and hamlet in the United States, resources are made available to scientific investigators that could be commanded by no commercial agency or for that matter by any government on earth. Finally, in addition to being widely diversified and ubiquitous geographically, it may again be emphasized that amateurs are technically self-trained, making the results of their observations competent and valuable.

It may be well to emphasize here a not-too-thoroughly-appreciated angle on the amateur relationship with technical radio research. While it is generally conceded that the great numbers and diversification of amateurs makes of them a uniquely-valuable adjunct to the basic field of advanced radio research, another important quality is not so generally recognized. This quality is the very freeness of spirit with which the amateur meets the problems he encounters in his peregrinations into the radio field. Great as are the attributes of modern organized laboratory research, it must nevertheless be admitted that laboratory developments by highly trained technicians following routine research practices are often encumbered with ponderous fetishes, impressive and involved mathematics, and the conviction that results can be obtained only by following certain rigorous routines. Amateurs break down these fetishes, which often lead to a singleness of mind that excludes the correlative detail that is often most significant in appraising new phenomena. By the very fact of their limitations in formalized training and laboratory equipment and technique, and the need to secure results by simpler methods, they free the art from many ponderous superstitions and often find the true answer to the problem which many are seeking. Many examples of this particular psychic or psychological phenomenon -- call it what you will -- exist, not only in radio but in allied fields of endeavor. The whole spirit of organized amateur radio trends toward this type of thought in technical matters, and it can safely be said that in no other field of endeavor has there been such free and untrammelled experimentation, unhampered by traditional prejudices, as has resulted from the amateur tradition in the radio art. Its effects are encountered not only in purely amateur circles but in the engineering field whose personnel, being often of amateur extraction and frequently of current amateur interest, retain much of the amateur spirit.

The Amateur Spirit in Research

This thought can be developed somewhat further. America leads the world in radio technological research. Many reasons for this pre-eminence have been advanced. We submit the thesis that the fundamental and underlying cause is the basic spirit of amateur radio that pervades the entire radio art in this country. We are informed by members of the military that for their purposes an operator of amateur extraction is universally superior to one of any other origin; more, that he is especially better than, for instance, a former land-line telegraph operator. Analyzed, their reasons come down to the essential fact that the amateur is <u>interested in the art</u> -- every detail of it. Radio is, to him, not only a vocation but an avocation. This characteristic makes him ten times as valuable as the professional operator, whose mind is simply a machine for the transcription of code signals without spontaneous, voluntary, personal interest in his work. The same characteristic applies in every other branch of the radio art. The typical radio engineer who is an amateur, it is generally agreed,

has the inquiring mind and unfettered viewpoint that lead him to try anything -- and it's a system that works. The chief engineer of one of the largest radio organizations in the country has stated informally that he reads two radio publications -- the recognized engineering journal for facts, the amateur's journal for ideas. Do we need any better insight than this into the minds of our radio engineers to appreciate the fundamental importance of the amateur spirit in our professional radio activities?

We submit it as a fundamental argument for the amateur that the status of the radio art to-day, and America's dominance in technological radio fields, derive fundamentally from the institution of amateur radio; that, directly and indirectly, every advancement in the art can be traced to basic amateur origins.

An institution of such potentialities for progress must, in all reason, be preserved. But amateurs contribute to the public interest, convenience and necessity in other, more tangible ways, to an extent sufficient to establish their indisputable and indispensable utility as a communications system, apart from their technological value.

Invaluable Communication Service in Public Emergencies

Perhaps the greatest public service of amateur radio is its ability to supply communication in time of emergency when all other means fail. There is never a year when some portion of our far-flung country does not experience an emergency through some act of nature which destroys the usual forms of communication and leaves a section of our population in dire distress, cut off from the usual means of aid. In such emergencies, amateurs may be counted upon to supply communication, even under the most difficult circumstances. With them it is a matter of pride and of solemn duty. Their vast numbers, their long experience in doing the impossible, their ingenuity in devising artifices, make it certain that with an adequate amateur body, no section of this nation can become isolated and its needs remain untold, even though days elapse before the public services are able to restore communication. The amateur body is trained in rendering this service and the Army and Navy, Coast Guard, Red Cross and state and city officers have come to look to it for this assistance. The chief instrumentality in supplying this communication is the Army-Amateur Radio System, an organized network of many thousand specially-selected stations created by a liaison for this particular purpose between the Signal Corps of the Army and the American Radio Relay League, particularly on behalf of the American Red Cross and of the Army's traditional duty to follow up the Red Cross in more serious emergencies. This network is organized to concentrate its communications upon the three relief headquarters of the Red Cross at Washington, St. Louis and San Francisco, and is kept in a high state of proficiency by weekly drills. The Naval Communications Reserve, made up of amateurs, similarly functions on behalf of the authorities in time of emergency. Other groups of amateurs serve the Coast Guard, the press associations, and an adequate number can always be counted upon to handle the needs of municipalities and the urgent inquiries of people seeking to learn of the safety of their relatives and friends. Since 1913 we have a record of several score emergencies in which amateurs have supplied the chief and frequently the only communication during the critical period when it was necessary to report the situation and arrange for relief. Thousands of lives, an untold amount of human misery, and millions of dollars in property have been saved by this means. We shall not here make any endeavor to recount this long list of important public services by amateur radio but we do hand in now, for the record and for your subsequent perusal, a list of the more important of these incidents. We do believe that the Commission would be interested in hearing of one of them which still looms fresh in the memory of all of us, the great flood of 1936. There is a dramatic story of the amateur's participation in this emergency.

A significant fact in connection with the March flood emergency is that unquestionably a far smaller loss of life was experienced than in any previous cataclysm of equivalent magnitude. It is estimated that there was perhaps a billion dollars in property damage, a half million persons homeless, hundreds of thousands destitute -- yet the Red Cross reports a total loss of life of only 214 persons. Probably the fundamental reason for this fortunate state of affairs was the effective emergency communications system that sprang up spontaneously, enabling (1st) prompt warning of the authorities, (2nd) immediate evacuation of threatened areas, and (3rd) undelayed provision of relief and rescue aids. By far the greater part of this emergency communications system was composed of amateur stations. Prior to the actual emergency the American Radio Relay League issued preparedness instructions, and when the crisis first became apparent amateurs were immediately on the job. As the danger spread to area after area, the emergency communications system expanded flexibly and spontaneously, until at the peak it is estimated that a thousand amateur stations were engaged in emergency activities. From Johnstown, Pennsylvania, along the Conemaugh, at Pittsburgh, down below on the Ohio; eastward, on the Susquehanna and its tributaries; then throughout the New England states, the amateur networks sprang into being, spontaneously, effectively, reliably. To a certain extent they were based on existing systems -- the Army-Amateur and Naval Reserve networks, the A.R.R.L. Emergency Corps -- but many came into being on an entirely unrehearsed basis. In Pennsylvania one amateur became the focal point for nearly one hundred stations operating in the amateur 3900-4000 kilocycle radiotelephone sub-band through mutual and practically unspoken agreement. The same thing happened in other places, under all sorts of conditions -- along the Merrimack, in "Governor Bridges' New Hampshire Network"; in the metropolitan Hartford district, where voluntary emergency organization reached a high point of development; in various networks organized for public utilities, notably that for the Connecticut Valley Power Exchange, and others. The immediate general insight that recognized and evaluated needs, selected the most strategic locations and the best operators, and the unquestioning delegation of authority to the man on the spot -- these were the remarkable and distinguishing characteristics of amateur radio operation during the flood emergency. Without such organization the work could not have been effective. Yet amateurs can be depended upon for the spontaneous recognition of duty and the technical skill and operating ability to discharge that duty reliably and speedily. Need for such service has arisen scores of times in the past twenty-five years. Amateur radio has yet to be found wanting.

Assistance to Expeditions

Another communications field that has relied almost exclusively upon amateur collaboration is that of scientific expeditions and exploring parties. For obvious reasons, normal communications facilities in many cases do not avail such parties. Never knowing just where or how they will be able to communicate, through the ubiquitous availability of the amateur system it has been possible, for a period of more than twelve years, for any exploring party wherever it may be to contact an amateur station through whom they can keep in touch with the homeland and transmit the vital information of their location and needs. The first expedition to use radio equipment for communicating purposes was that led by Commander Donald B. MacMillan in 1923. On this expedition the American Radio Relay League sent Donald H. Mix, operator of amateur station 1TS, one of its most skilled members, as an operator. So successful was this undertaking that since that time practically no expedition has taken the field without radio equipment, often of amateur design and usually operated by amateurs. For the most part, they have depended largely upon amateur radio for their contact with civilization, maintaining nightly contact with the far-flung network of amateur stations covering the country. Among these parties are the Byrd Arctic Expeditions, the first Byrd Antarctic Expedition, the annual trips of such famous Arctic explorers as Captain MacMillan and

Captain "Bob" Bartlett, the various expeditions sent out by universities -- in fact, almost every party of exploration that has gone out to explore the frontiers of the unknown in recent years. The total number of such expeditions mounts to more than a hundred, covering exploration in every continent, and from the equator to both poles. Without amateur radio the world would not to-day have as much of the knowledge and benefits gained through scientific exploration, dependent for its success on the communications facilities available.

Message Relaying

In addition, since 1914 the League has furnished a free message service to the public, without amateur responsibility for delivery, the figures for which in a typical year show a reported total of nearly 900,000 relays and an indicated number of actual messages handled and delivered of 175,000. Although many of these messages were in themselves of considerable public value, where they were received through amateur supplementation of existing communications systems as in the case of emergency work, they are of most particular value in the training in operating procedure afforded the amateur operators concerned. In this connection it is of interest to note that the typical amateur message is handled by at least four operators, and thus has a potential training value of four or five times in typical amateur relaying.

These are, in the main, tangible performances, subject to factual analysis and statistical discussion. There are other considerations, of an intangible nature, that must also be borne in mind in arriving at a true evaluation of the worth of amateur radio in terms of its contribution to the public welfare.

Improving International Amity

One of these less tangible things is the advance in international understanding which is being created by the contact of amateurs in practically every country on earth. It is impossible to have tens of thousands of citizens of the various nations of the world in constant communication with each other without making some substantial contribution to better relations. The average American amateur makes scores of contacts every year with amateurs in other lands, and friendship follows communication. Amateurs have their own international organization, as well, which augments fraternalism -- the International Amateur Radio Union, a federation of national amateur societies, in existence since 1925 as a vehicle for international co-operation between 26 national societies similar in scope, though not in dimensions, to our American Radio Relay League. Although it is admittedly impossible to evaluate such intangibles, it must be conceded that this general atmosphere of "hands across the sea" makes for better understanding and more amicable relations between nations. Of particular importance does this aspect become when it is realized that, in other countries, the licensed transmitting amateur is usually the highest type of individual, often mature, and almost inevitably of a certain economic independence. This type of international intercourse is of the highest type, for it eliminates all selfishness, all credos, all materialistic or propagandistic motives, and aims only at the cultivation of international amity based on direct human friendships.

Self-Improvement

Nor should we lose sight of the sociological importance of the institution of amateur radio. In this respect its most important asset is of course the self-improvement of the individual. Amateur radio teaches method and industry, encourages the inquiring mind and the reasoning processes, teaches self-reliance and consideration of the rights of others.

In such respects it far transcends the usual hobby, for it is a training school in which the tools are those of universal science. It may sound like an ambitious assertion but it is true that he who becomes an amateur ceases to be a social problem. Reflecting that our culture is as good as the individuals who comprise it, much must be said for the sociological importance of amateur radio.

Appreciations

The accomplishments of amateur radio have received high praise from many leaders in our nation in the fields of science, government, the press, and so on. We have tabulated in a separate exhibit some of the tributes that have been paid amateur radio by such men as the President of the United States, ex-President Hoover, the Departments of War and the Navy, the Governors of several of the States, and from a number of other individuals holding high positions in government, science, industry, and other walks of life.

No other nation enjoys the benefits of the institution of amateur radio to the extent that the United States does. Limited by smaller population, poor economic situations and chiefly by an unenlightened point of view, amateur radio has never enjoyed the same opportunities to demonstrate abroad the qualities that it has displayed in the United States. It is incontrovertibly established, we believe, that the policy of this nation in assigning amateurs a group of frequency bands of reasonable width has richly repaid the nation.

III - THE AMATEUR'S OPERATING STATUS AND HIS LOW-FREQUENCY NEEDS

This section of our presentation is a review of the present practical operating situation in amateur radio and the future needs of that service in the frequencies below 30,000 kc. It also treats two items in the Commission's agenda for these hearings: 2a, the frequency bands required for a given service and their exact position in the spectrum, the width of communication band or channel in each portion required for station frequency assignments; 2b, suitability and necessity for particular portions of the spectrum for the service involved, taking into consideration propagation characteristics.

Amateurs operate in bands of frequencies. It is neither feasible nor desirable to assign them individual channels or frequencies. Certain bands of frequencies are made available for amateur radio and every amateur is authorized, by the terms of his license, to operate at will anywhere within these bands, always provided that he confines the effects of his signals within the limits of the bands and provided that the nature of the signal complies with certain generic stipulations of the regulations as to quality, type of emission, power, and so on. Amateur radio fairly well polices itself, both personal pride and the critical opinion of his fellows conspiring to make very amateur endeavor to have a signal of optimum quality. Thus our service is not concerned at this hearing with such factors as the width of the communication band or channel or the tolerances of frequency instability for individual stations; we are concerned only with the dimensions and locations of the various amateur bands. However, we shall explain for the Commission's information the purposes for which the different amateur bands are used, and something of their general characteristics.

A Brief History of Amateur Allocations

It should be said in introduction that there was a time in the radio art when all the frequencies above 1500 kc. were regarded as worthless. The successful practice of those days required huge antennas, and very large condensers to hold the electrical energy, and the result was a long wavelength or low frequency. When amateurs were first required by law to limit themselves to frequencies above 1500 kc. it was done with the thought of relegating them to obscurity, which in those days was thought to be a good idea. On such frequencies it was believed that amateurs would no longer be able to "work outside of their own back yards". Thus the whole world of frequencies above 1500 kc. was once at the disposal of the amateur. By the year 1921, amateur technique had reached such an astounding development that signals on these frequencies were being heard for thousands of miles. Determined to explore these possibilities, the League sent to Europe one of its most skilled members, with highly effective amateur receiving apparatus of his own devising, and organized tests in which coded transmissions were sent by American amateurs while he listened. That amateur was Paul F. Godley, now a consulting engineer practising before this Commission and doubtless known to most of you gentlemen. His success in copying the signals of dozens of American amateurs in Scotland electrified the scientific world and demonstrated beyond cavil the value of the frequencies theretofore regarded as worthless. Roaming upward in frequency through their territory, in another two years amateurs accomplished the really startling thing of harnessing the higher frequencies, whereby two-way transocean communication to the more distant portions of the globe became a commonplace, even with very low power. There followed a great influx of commercial and governmental services of every description into the high-frequency field, a regular gold rush for the amateur's theretofore worthless frequencies. Now the amateur did not need all of these

frequencies above 1500 kc. nor did he wish to stand in the way of other radio groups that might render an improved public service by taking advantage of the superior characteristics of these high frequencies as demonstrated by his pioneering. The amateur would be content with a series of wide bands of frequencies located an octave apart through the frequency spectrum. These developments occurred at a point in the history of radio regulation in this country when governmental control was in a precarious state because of the insufficiencies of the Radio Law of 1912. The de facto radio administration of those days was a series of annual national radio conferences, where the divers American radio groups met and by voluntary agreement worked out plans which were then promulgated by the authorities and which were workable because they had received unanimous acceptance in advance. Under this strictly American arrangement, the amateur received frequency allocations which were entirely adequate for his numbers in those days and which, by virtue of technical progress since, would be regarded as generally adequate to-day. We shall refer more specifically to this matter in a few moments. In 1927 there was held in Washington the first international radio conference since the one which resulted in the London Convention of 1912. At this conference an international determination of the bands to be assigned to amateurs was made, resulting in the establishment of these assignments at approximately half of their former values, to be effective the first of 1929. With the continual increase in the number of amateurs, not only in this country but in most other countries of the world, these assignments have become thoroughly inadequate, as we shall shortly demonstrate. But out purpose at this moment is to point out that all amateur assignments, ever since the amateur's original holding of all frequencies above 1500 kc. was subdivided amongst the various services, have been in terms of bands of definite widths each an octave apart in the radio spectrum. By an octave apart we mean that each succeeding band is of approximately double the frequency of the one that precedes it. That is to say, the amateur assignments are a family of harmonically-related bands. There is an essential reason for this. The different frequencies have different performance characteristics and are useful for operating at different distances at different times of the day and at different seasons. This in fact is a principle in the allocation of frequencies to all services in this portion of the spectrum. Amateurs are investigators and experimenters, and to enable them to carry on their contributions to the art, and their communication enterprises which are so helpful to the nation, it is vital that they possess allocations having these different characteristics which are to be found every octave through the high-frequency spectrum. Thus from the standpoint of the Commission's allocation problem it may be said that the principle is to give the amateur experimenter test slices from each region of the spectrum, so that he may investigate their potentialities and have at his disposal frequencies for any given job. Herein we have enunciated the first great principle in the allocation of frequencies to the amateur service: amateurs are assigned bands of frequencies, not individual channels, and in the portion of the spectrum in which they are interested these bands should be allocated substantially an octave apart.

The Amateur's Place in the Spectrum

We show you now a chart (Fig. 1) which is an attempt to show in one block the entire usable radio spectrum, arranged as a family of broad harmonic relations. This is substantially sound as to principle, because in general terms the space in the spectrum occupied by any station is a function of its instability, which is commonly a percentage of its frequency. For example, suppose a signal at 5000 kc. has an instability of one-hundredth of 1 percent (0.01%). That signal then may be found anywhere within a range of 1000 cycles, or 500 cycles on either side of 5000 kc. But if the frequency is doubled to 10,000 kc. and the same stability obtains, the signal may be anywhere within a range of 2000 cycles, or 1000 cycles on either side of its exact assigned frequency. Doubling the frequency made it necessary to allow the signal twice the

spectrum space it previously occupied. And at 20,000 kc. and the same stability, one would have to allow 4000 cycles for that signal. This principle is recognized by the Commission in prescribing separations between assigned frequencies. Allowing also for modulation and guard bands, you separate assigned frequencies by 5 kc. at 5000 kilocycles, 10 kc. at 10,000 kilocycles, and 20 kc. at 20,000 kilocycles. Our chart follows this same principle: that when the frequency is doubled, the space occupied by the signal is doubled. Running from 10 kc. to 512,000 kc., each succeeding horizontal division represents twice as many kilocycles as the division above it, yet is capable of accommodating substantially the same number of stations. On this chart we now show you the location within the spectrum of the amateur bands. It will be noted that these bands are essentially a harmonic family, in that they are a cluster, one below the next. They aggregate approximately only 7% of the frequencies below 60,000 kc., although amateur stations amount to approximately 92% of all U. S. radio stations.

We ask you to note now these six amateur bands, their approximate shape, the fact that they are substantially flush on their left-hand edge. We show you now another chart (Fig. 2) which is an enlarged rendition of this harmonic family. This is the amateur world. We want now to tell you how we employ it, what the various bands are used for, and something of the density of our occupancy.

How the Amateur Bands Are Employed

All the amateur bands are open to radiotelegraph operation. Certain portions of these bands are open to radiotelephony. Since a telephone signal requires approximately six times the spectrum width for satisfactory operation and thus creates proportionately greater interference, the parts of the bands in which voice work is permitted become in practical effect exclusively radiotelephone.

The 1715-2000 kc. band is most used for moderate-distance voice communication, and to a lesser degree for telegraph work. Under favorable winter night conditions this band can be used for communication up to 1200 or 1500 miles but is normally useful for not over 500 miles.

In the 3500-4000 kc. band the most important domestic amateur activity takes place. Organized relay routes and trunk lines, emergency communication tests, volunteer operator training in connection with the Army-Amateur Radio System and Naval Communication Reserve, state and section networks of stations keeping schedules and prepared to render expert cooperation with civilian and governmental agencies in the face of any emergency -- these are the most noteworthy uses of this band. Under winter night conditions these frequencies are useful for coast-to-coast work. Under less favorable conditions reliable work over several hundred miles is possible. Twenty percent of the band is open to voice as well as telegraph operation. Class-A or restricted telephone operation, by those individuals passing a special theory examination and possessing previous experience, is designed to limit this work to the specially qualified, while the 1715-kc. band is more a "beginner's" band. Its largest field of usefulness is for reliable communication over medium distances. As we shall show, the high degree of occupancy of this amateur band produces a high degree of congestion. Its assignment to amateurs and its field of usefulness as demonstrated in emergencies again and again for many years is indicative of the high degree of public service inherent in this assignment, this accomplished despite high interference levels there. This is the band used by organized amateur operators of the highest type; work there develops telegraph operators of the highest skill for the services; this band has been demonstrated to be the most important for use in domestic emergencies of all kinds due to having the most satisfactory distance and "skip" characteristics over the years and the different seasons of the year. The large number of operators constantly on the alert insures that

every frequency is constantly covered (in tuning) by many other operators -- vastly better potential emergency circuits thus obtaining than can be secured by any other means entailing even large emergency expenditures for personnel.

The 7000-7300 kc. band is consistently used in international communication, in addition to carrying a large volume of daytime domestic contacts and transcontinental work at hours when this is impossible on lower frequencies. It is an important band for contact with United States possessions. As will be noted from a subsequent chart, the congestion in this band is even greater than in the 3500-4000 kc. band just under discussion. Frequencies in this region are most essential to amateurs to permit long-hop contacts between remote sections of the country which might otherwise become isolated in emergency. Because this band is international in effect and contains amateurs of all nations, it is most intensely populated. Due to its narrowness in comparison to its wide use, no telephone work has been permitted domestically within its limits, but the interference level has been increased in the last season or two by some telephone use by amateurs of other countries where regulation is not as carefully drawn as in the United States.

The 14,000-14,400 kc. amateur band permits transcontinental communication in mid-day and exceptional night-time distances in international work. Twenty-five percent of this band (like our 3500-4000 kc. band) is open to radiotelephone operation to those specially qualified. Successful communication on these higher-frequency bands is somewhat more subject to fluctuations in conditions with the sun-spot cycle than is the case with the lower frequencies. Problems of stray feedback in transmitters and greater difficulties in maintaining satisfactory frequency stability make successful technique somewhat more difficult to master. While once considered "spotty" in operation, this band has now developed excellent year-'round characteristics for dependable two-way work across the country, and internationally it is superior to any lower frequency.

Coming to the 28,000-30,000 kc. band, this is open in its entirety to telegraphy, the basic form of amateur radio, and 50% of the band is available for unrestricted telephone work. Reliable for local communication, it shares many of the useful characteristics of the ultra-high frequencies, and also for considerable periods sky-wave communication of the most substantial and excellent character obtains. In such periods this band carries a heavy load of international communication, both voice and telegraph. The 56,000-60,000 kc. band is regularly used for local amateur work, and these two bands carry a large degree of experimental interest which amateurs are developing to the utmost. Like the 28-mc. frequencies, there are occasional lapses when distant work over many hundreds of miles becomes possible. At present amateurs also operate jointly with other services and temporarily on all frequencies above 110 mc. and have an exclusive assignment from 400 to 401 megacycles, this being used for experimental investigations and experimental communication.

Amateur Numbers and Their Congestion

We have briefly sketched the characteristics of the different parts of the spectrum assigned to the amateur service. You have issued approximately 45,000 amateur station licenses to individual citizens who have qualified by code and technical examination and you will be interested to know something further of the occupancy and use of the different frequencies by amateurs. A few operators are equipped for a single amateur band and use that one band for practically all their operation. Operators increasingly, however, are equipping themselves with apparatus of flexible design suitable for working two or three or even more bands in order to avail themselves of the best characteristics of each at the proper times and seasons, and when confronted by a definite communicating problem. We amateurs make most intensive use of all our frequency bands and the dis-

tribution of our stations in any given location over the whole band insures the most successful work with a minimum of local interference.

Our next chart (Fig. 3) shows the relative amateur occupancy of the different low-frequency amateur bands -- and also the number of "F.C.C. channels" contained in each band according to the frequency width specified for a channel by your Engineering Department. You may have wondered how amateur operation obtains at all where so many stations have to use the same channels to maintain communication. The automatic distribution of stations from one end of the band to the other, together with the beneficient value of "skip effect", somewhat reduces the mutual interference during even the hours of heaviest operation. The ground wave is minimized in importance and sky-wave communication is possible without too much interference from stations in the same local area. Amateurs thus use all their bands with highest efficiency and render creditable performance in spite of interference, which does indeed reach terrific levels. An intensive survey to determine our station distribution has been made by the League. The survey figures represented a registration of band occupancy and use by several thousand individual amateurs. The percentage use of different bands by each individual has been carefully integrated to show overall interest in each different frequency band and give a true picture of amateur operating. The percentage of interest and use shown have then been applied to the assumption that all amateur operators use the bands in just the same fashion as this large cross-section of the amateur fraternity.

Of 45,000 stations licensed, you will note from the chart that 3800 may be considered as interested in the 1.7-mc. band assignment, 19,000 in the 3.5-mc. band, 12,500 in the 7-mc. band and 7,280 in the 14-mc. band assignment -- these bands representing but 72, 101, 31, and 27 "F.C.C. channels" respectively!

We do not, of course hold that at any one moment all 45,000 station licensees are active on the air. A large number are, however, and we have by a different series of surveys, made by contacting every single licensee in a given area, proved quite conclusively that one-third the total number of licensees are active in any given month of the year. At times when various tests are in progress (and the League sponsors different activities to interest members, increase skill and attain definite operating and experimental objectives) a very high amount of activity obtains. While the total of all amateur interest divides as shown in the circle at the right of the chart, a practical measure of the maximum interference that obtains may be indicated by considering the number of stations on the air as very close to one-third of the total number of licensees.

In the fixed service you assign each station a channel. In our service, occupancy varies between 50 and 400 stations for each standard F.C.C. channel. This, the occupancy for each of our different low-frequency bands, we have shown in terms of F.C.C. channels on another chart (Fig. 4). The density of occupancy of each band has been obtained by dividing the number of stations shown by our surveys as correct occupancy for the band by the number of channels in that band.

More Frequencies Are Needed

Fifty-four stations to each channel is then the measure of congestion in our 1715-2000 kc. band. In the very band which time and again demonstrates its emergency value (3500-4000 kc.) the number of users per channel is much greater, rising to 189 stations. For the 7-7.3 mc. band, used internationally, there are over 400 stations per channel, and for the 14-mc. band 269 stations per F.C.C. channel. Referring back to our previous chart you will note the tremendous number of users of the 3500 and 7000 kc. bands, which occupy the larger portion of the disk to which we

called your attention. It is these amateurs, the majority of the users of these two bands, that most clearly suffer from interference and congestion. We need extension of the frequency territory in the 3500-kc. region to alleviate the interference which exists there and, as shown on the chart, we need an extension of the 7000-7300 kc. band even more. The operation on each channel in this band exceeds all others. Although occupancy of our 14,000-kc. band also looms large, actual congestion in operation there is not as severe as in the lower-frequency bands because of the much greater skip. As one goes lower in frequency the protection from skip is progressively less, the interference worse, until it is a living nightmare on 7000 and 3500 kc.

In noting our occupancy and the congestion which results therefrom on account of the shared use of channels and the limitations in the size of our bands, we have discussed the occupancy by United States amateurs only. It must be remembered that Canada and Mexico share our bands on the North American continent and contribute substantially to the interference levels, especially on the low-frequency amateur bands. In the southern part of the country the signals from 7- and 14-mc. Canadian amateurs contribute to the picture, and the same situation for northern amateurs exists with respect to Mexican stations using these frequencies. All foreign amateurs use the high-frequency amateur bands extensively and our frequency needs must take them into account.

We would like to digress a moment to show you another chart (Fig. 5). This chart illustrates, in outline, the size of the amateur bands as they existed prior to 1929, when the Washington Convention went into effect, and, in color, the bands as they have since existed. It is a sort of example of "before and after taking." You will recognize the colored portion as constituting the family of amateur bands that we have just discussed, and you will note that it is a terrific reduction from the former size of those bands. At the time that reduction occurred, the number of American amateurs was 17,000, while to-day it is 45,000. Foreign amateurs then numbered approximately 10,000, as against 20,000 to-day. Yet it will be seen that this increased number of amateurs must now accommodate themselves in an allocation only 52% as great as they previously enjoyed, and that this is all that remains to them of their once proud heritage of all the frequencies above 1500 kc.

The Severity of Interference

From the earliest times, the amateur has been accustomed to interference from other amateur stations. He does not expect freedom from interference, as do commercial services. Interference is the rule and not the exception in amateur work. A little of this is a good thing, as it is a not unwelcome test of skill and is what has given the amateur operator a better ear for reading desired signals through interference than is possessed by any other operator. But the almost unbelievable congestion of occupancy, which we explained by a chart a moment ago, has produced a condition to-day which is almost intolerable for the average amateur. It is no infrequent thing to find amateur signals "six deep" on a given frequency, with only the loudest one readable, the buzz of other signals to be heard only when the loudest one pauses. Driven by force of necessity, amateurs have developed what is probably the most selective receiver in use to-day. The crystal-filter single-signal receiver, developed by Mr. James J. Lamb of our headquarters staff, is actually capable of discriminating between stable telegraph signals differing by no more than a hundred cycles. But these receivers are still relatively very expensive, much beyond the price of average receivers, considerably beyond the reach of average amateurs, so that it cannot be expected that they will come into universal use. Almost all amateur transmitters to-day are crystal-controlled. In fact, the order of performance of most amateur gear, both transmitting and receiving, is superior to that of most other services -- it has to be. Despite such standards, the interference is now of such proportions that it constitutes

the major item of discussion in amateur circles. The need for some relief is urgent, the hope great. During the evening hours it is rare for average amateur stations to be able to converse more than a few minutes. They establish contact, only to be drowned under layer after layer of additional amateur signals. We have previously referred to the great value which we attach to our liaison with the Army and Navy, thousands of our members associating themselves with the emergency nets and training reserves of these services, drilling themselves each week with their own stations. Despite the fact that we are intensely proud of our connections with the services, our congestion is so severe that a year ago we felt obliged to ask the services to search for some arrangement whereunder they could make available a few government frequencies for these drills, and take the same out of our bands. Every device we can think of is employed to better our operating conditions but the interference to-day is so severe as to constitute a sad discouragement to all but the most hardy souls. The occupancy figures that we cite above speak for themselves, and it does not seem necessary for us to belabor the point. Although we never expect freedom from interference our present situation, in the vernacular, is "just too tough". We believe it is obvious that we are now handicapped in performing our aids to the nation. It is really a marvel that, under the existing conditions, the amateur is able to supply the emergency communication and other services that he does, and that he is still sufficiently encouraged to carry on and make his contributions to the art.

Future Needs

To afford the relief needed to continue the best contribution to American life, there are two amateur bands in the portion of the spectrum under discussion that ought to be widened. We show you a chart (Fig. 6) which illustrates these additional needs. The band at 4000 kc. is the one which carries our organized domestic communication at moderate distances, and we share it with other amateurs in the North American region who have the same assignment. It is our most important band, where occurs the bulk of the important communications service which has previously been discussed. It is, in fact, the heart and very life of amateur radio. It is so crowded that we feel that it needs to be doubled, in order to permit us to render a satisfactory service. If it were thus doubled as indicated on this chart, the total assignment to amateurs in the two low-frequency bands which are useful for working at moderate distances (3500 and 1715 bands), would only be approximately what they were prior to 1929. The other respect in which amateurs desperately need more frequencies is in the 7000-kc. band. This band is employed for long-distance communication. It is internationally assigned exclusively to amateurs and is used by the amateurs of every nation. It is the chief band for foreign communication and is also used for longer distances within this country. Because it is international in its effect, a very narrow band, and filled with the signals of every nation, the congestion here is most intense. If this were widened as indicated on this chart, it would still have but half the width it possessed prior to 1929, when the number of amateurs was much less.

With respect to our need for more frequencies adjacent to our 7000-7300 kc. band, we would like to say that we have made a considerable examination of the uses to which these adjacent frequencies are now being put. The March, 1936, edition of the Frequency List of the Bureau of the International Telecommunications Union shows that between 7300 kc. and 7500 kc. notifications of operation have been filed to a total of 293. In this list we find 47 stations that are merely projected or are still in course of construction, leaving 246 stations that are purportedly in operation. We illustrate this with another chart (Fig. 7). A few of the stations listed are amongst the major communications of the world, including some of the chief circuits between this country and others. But of the total we find that 172 of the notifications are for a registered power of less than 250 watts, 21 are between that and a kilowatt, 23 are between 1

and 5 kilowatts, and only 30 are more than 5 kilowatts. During the past year several hundred amateurs, interested in the possibility of increasing our allocations, have collaborated as observers in a surveying plan which our organization has carried on, in which we have made some attempt to examine what is going on in these frequencies. These hundreds of observers have submitted some thousands of reports, containing some tens of thousands of observations made in all parts of the nation and some of them on the other side of the world, at all times of the day and night. Some of the observers worked as individuals, some worked as groups and made correlated reports. Our considered opinion, after analyzing the data, is that, from the engineering standpoint, the allocation system being followed in this portion of the spectrum is an inefficient one, and that if sound engineering considerations could be made to govern, it would be readily possible to increase the frequencies of amateurs without hardship to other services. Let us report a few of the facts we have observed:

Additional Space for Amateurs is Available

Of the 246 stations notified to the Berne Bureau as operating between 7300 and 7500 kc., in a year's observation our observers have been able to hear only 50 different stations. The distribution of these, in terms of registered power, is indicated by the shaded portions in this chart. We have heard almost all of the stations of substantial power, a goodly percentage of those of intermediate power, but only a very few of those in the most numerous class, those of low power. The other stations, if they exist, operate but briefly with but little communication, or in exceptional instances are beam stations that cannot be heard in this country, or else the range of the stations is so limited that it becomes obvious that they could be accommodated at any other location in the spectrum without mutual interference. Indeed, it is only this ability to sandwich in numerous lightly-loaded circuits of low power almost anywhere that permits a total of 246 notified stations to carry on in a band which, by this Commission's practice, contains only 21 channels. We have become convinced from our survey that this region of 7300 to 7500 kc. is to be thought of, from the American standpoint, not as the working territory of about 300 stations but as that of about 60 stations. We have also made an analysis of the operating time of the stations that we have heard, whether they were being used to transmit traffic or were idling with some device to maintain the circuit while waiting for another message to be filed. These figures show that these commercial stations, during the time that they are on the air, spend only about 40% of their time in the actual handling of traffic and about 60% in idling, sending V's or otherwise "holding the circuit". Now we appreciate the importance to American life of the major radiotelegraph circuits; we know that civilization follows communication and that the needs of our nation require the most effective form of communication with other nations; and we also recognize that these major circuits must compete with cables and therefore must hold open their circuits so that they are similarly able to transmit a message instantly upon its filing. But it must be pointed out that the great majority of the frequencies notified in this band are not occupied by stations of any major importance and we submit that they simply do not make an economical use of their frequencies. It is very questionable engineering. The total volume of the communications handled certainly could be accommodated by a very small percentage of the existing stations. We admit the existence of serious political and administrative difficulties in effectuating any more economical distribution and use of frequencies but we feel that we must insist, from our surveys, that from the engineering standpoint it would be readily possible to compress the fixed service within a slightly smaller portion of the vast stretches of allocations now enjoyed by it, without in any wise impairing its efficacy. Thereby there could be provided to amateur radio a small increase in this region which it very badly needs.

IV -- ULTRA-HIGH-FREQUENCY INVESTIGATIONS BY AMATEURS

It is our purpose in this section of our presentation to acquaint the Commission with the results secured by amateurs in operation on the frequencies above 28 mc., with some particulars of the apparatus and methods used, together with a discussion of numerous questions raised by the Commission. Because amateurs are experimenters and investigators working amongst themselves in bands of frequencies, many of the Commission's questions do not apply to amateur radio and obviously were intended for commercial services requiring specific channel assignments. This is true, of course, of the Commission's questions concerning the degree to which our service should be made available to the public, the probability of its practical establishment and the public support thereof, the width of communication bands, the points with which communication will be maintained, the number of stations required, and the distance over which communication must be maintained, etc.

On the engineering angles we hope that some of the information disclosed by our studies may be of interest.

The Various Modes of Propagation

In any discussion of the very high and ultra-high frequencies, we have found it very desirable to distinguish carefully between the various modes of propagation concerned. The wave in which the radio art is most interested on the high frequencies is that propagated in the ionosphere and, hence, usually termed the "sky wave". The bending in the ionosphere which gives us this sky wave decreases with increase in frequency and, as we approach the ultra-high-frequency region, the bending becomes so slight that the signal is not always returned to earth. Indeed, on frequencies higher than 30,000 kc. the sky wave cannot be depended upon for reliable communication during any particular period of the day. Another mode of propagation which has received wide consideration, particularly on the ultra-high frequencies, is by means of the "ground wave". The received wave in this case is that portion of the transmitter field which travels directly -- on the line of sight -- between the transmitter and the receiver. Still another mode of propagation, and one which has been given very little attention, is that made possible by those waves which travel in the lower regions of the atmosphere and are bent around the curve of the earth's surface and over mountains and other obstacles by stratification in the atmosphere itself. Waves in this category, it is our intention to show, may at times travel appreciable distances with surprisingly low attenuation, and a consideration of their effectiveness is, we believe, essential in any study of the interference range of ultra-high-frequency transmitters. Waves transmitted in this manner will be termed "air waves".

The published studies of ultra-high-frequency propagation have been concerned chiefly with the reliable coverage area of ultra-high-frequency signals. There has been, we believe, a rather serious neglect of the very necessary observations beyond the regions of steady-signal coverage. This neglect has not only failed to give us an accurate picture of the long-range interference capabilities of ultra-high-frequency waves but has resulted in a thorough-going misconception on the part of the lay public and some sections of the engineering field to the effect that ultra-high frequencies travel only to the horizon and are limited to the line of sight.

Performance of Amateur Band 28-30 Mc.

These remarks are to be concerned chiefly with air-wave transmissions on the ultra-high frequencies, and treatment will be made chiefly of frequencies higher than 30,000 kc. However, it would be well first to consider the amateur band from 28,000 to 30,000 kc. This band, from the amateur viewpoint, is essentially an experimental long-distance band on which sky-wave propagation is given most attention. During 1928 there was considerable amateur activity in this band, transcontinental communication being relatively common, with occasional exchange of signals between the United States and various foreign countries. Since that time, groups of amateurs particularly interested in this band have had increasingly frequent experimental communication over long distances and have seen a steady improvement in those conditions in the ionosphere which are required for successful use of the band for long-distance working. For the past year the band has been yielding excellent results over all terrestrial distances in excess of approximately 500 miles. In addition to the long-time trend shown in the effectiveness of the 28,000 to 30,000 kc. band there is also revealed a seasonal variation which would appear to be in good accord with measurements of the height of significant layers in the ionosphere made by various scientific groups. Thus it may be said of this band that, during certain years of the solar cycle at least, it exhibits a sky-wave characteristic somewhat similar to the lower frequencies but that, since this characteristic is extremely variable, the value of the band is chiefly in providing experimental communication and allowing further study of conditions in the ionosphere.

Some idea of the effectiveness of the band may be had from the fact that, during the last year, approximately 50 amateurs have been able to establish communication with every continent, many of them doing it repeatedly on the same day.

Before terminating the discussion of this band -- which is actually below the limit set by the Commission for the beginning of the ultra-high frequency region -- it would be well to point out that air-wave propagation plays an important part. It is quite common for amateur signals on the 28,000 to 30,000 kc. band to be heard with considerable strength over distances between 50 and 150 miles. These signals are propagated, it is believed, by bending of the waves in the lower atmosphere.

Amateur Development of 56-60 Mc.

The lowest-frequency amateur band within the ultra-high frequency region is that from 56,000 to 60,000 kc. or at about 5 meters. Amateurs developed equipment for this band as early as 1925 and occupation of the band began at that time. Continued development of more effective equipment resulted in greater occupancy of the band and, by 1932, at least several hundred "five-meter" amateur stations were in operation. During the last few years occupancy of the band has grown very rapidly with the result that, in the larger centers, the band is now subject to severe congestion. The band is assigned for portable-mobile operation as well as for use by fixed and portable amateur stations and therefore has been employed by amateurs with portable apparatus operating from mountain peaks, look-out towers and tall buildings, and by amateur stations mounted in automobiles and motor-boats and even on airplanes and gliders. In general, with extremely low powers and simple antennas, the ranges achieved are not greatly in excess of the line of sight except under circumstances to be outlined later. Typical portable or mobile transmitters used by amateurs in this band are of the simple modulated-oscillator or oscillator-amplifier type with input power rarely in excess of 10 watts, used in conjunction with a super-regenerative receiver. Somewhat similar equipment is used at many fixed stations but the trend is toward the use of transmitters stabilized with resonant-line circuits or with crystal control and using higher power. The simple super-regenerative receiver is gradually

being displaced by various types of superheterodyne receivers, in many of which super-regeneration is employed in the interests of noise reduction and extreme sensitivity. With this improved equipment, amateurs operating fixed stations are no longer content with line-of-sight communication. With suitable atmospheric conditions, the range in routine amateur work has often been extended to two or three horizons. In the East, for instance, (Fig. 8) amateur communication circuits, operating with a fair degree of reliability, are maintained between such cities as Boston and Providence; Boston and Hartford; Waterbury, Connecticut, and New York City; New York and Philadelphia.

Sky-Wave Communication on 60 Mc.

More extraordinary still is the way in which amateur 60-mc. signals have occasionally been covering distances in excess of a thousand miles. Contacts over these long distances, of course, are probably the result of what we now believe to be abnormal conditions in the ionosphere. The fact remains that, on several occasions during the last twelve months, east-coast amateurs operating with very low-powered equipment have been able to communicate on 60 mc. with stations in the central states. (Fig. 9). These contacts have shown that the attenuation under these particular circumstances is of a very low order -- extremely strong signals being produced with simple super-regenerative receivers from transmitters operating with inputs of the order of ten watts. The most recent example of this long-distance communication on 60 mc. occurred on May 9th of this year. On that occasion, from 8:30 p.m. to midnight, E.S.T., scores of low-powered stations in the Atlantic states and New England established two-way communication with similar stations in the central states. Knowledge of the approximate sensitivity characteristics of the typical super-regenerative receiver makes it possible to estimate that the order of signal level prevailing under those circumstances possibly reached 50 microvolts per meter. This long distance communication on 60 mc. is, at the moment, a relatively rare occurrence. Observations of scientific workers engaged in studies of the ionosphere lead us to believe, however, that such conditions will recur with increasing frequency during the next few years.

The West Hartford-Boston Experimental Circuit

We shall proceed now to a brief report of the ultra-high-frequency experimental circuit which we have operated between West Hartford, Connecticut, and Boston since August, 1934. Since that date a program of daily observations of ultra-high-frequency signals has been maintained for the express purpose of studying variations in the signals from ultra-high-frequency stations at points considerably beyond the first horizon. During the course of this program chief consideration was given to frequencies of the order of 60 mc. Additional observations were made, however, on 240 mc., 112 mc., and 41 mc. The program was conducted with the close co-operation of Dr. C. F. Brooks of the Blue Hill Observatory of Harvard University.

The most important single project included in the program has been the recording at West Hartford, day and night for the last 18 months, of hourly tone signals transmitted from the Blue Hill Observatory from the experimental station W1XW operating on 60.5 mc. During this phase of the program more than 12,000 individual hourly tone signals were recorded. These records have since been analyzed in the attempt to establish a correlation between the variations in signal level and conditions in the lower atmosphere. The results obtained in this study have been the subject of technical papers delivered at the last two joint annual meetings of the International Scientific Radio Union and the Institute of Radio Engineers. We shall consider now the data resulting from this period of recordings.

The Blue Hill Observatory station, from which the tone signals are transmitted, is located on a hill 600 feet above sea level. A simple dipole antenna is used, approximately 60 feet above ground, and is excited by a conventional transmitter having an input power of 120 watts. Power for the transmitter is obtained through an appropriate voltage regulator.

The West Hartford terminal station is located 300 feet above sea level and, for recording purposes, uses a twelve-element directive array feeding a standard three-tube super-regenerative receiver. The receiver output is recorded photographically. The sensitivity of the receiver is checked from time to time with a standard-signal generator, while the overall sensitivity of the receiver and array is similarly checked with a standard-field generator. The receiving equipment is operated from an appropriate voltage regulator.

The path (Fig. 10) between the two stations is thought to be significant in the present discussion because of its length (95 miles) and because the radius of curvature of the clearing ray trajectory is approximately only 70% of the earth's radius. Intervening hills rise to 900 feet above sea level at several points and the path, as a result, can be considered to embrace four horizons. It is the common belief that reliable transmission over a path of this nature would not be possible on a frequency of 60 mc. or higher. The signal recordings for the 18-months period reveal only five occasions when the signal dropped below the level necessary for recording -- a level estimated at 0.5 microvolt per meter. These periods lasted not more than three or four hours and occurred invariably during the early hours of the afternoon. A general review of the recording shows that the signal is subject to almost continuous variation. These variations take at least four major forms. The first is rapid fluctuation over periods of one to fifteen minutes; the second, a well-defined diurnal change giving minimum signals during the early afternoon; third, a day-to-day signal variation apparently related to the movements, modifications, and intermingling of air masses; fourth, a pronounced seasonal drift giving particularly high signal levels during June, July and August.

Signal variations on the ultra-high frequencies at points beyond the horizon have been noted during brief observations by other workers. The purpose of this long-continued observation was to establish that such variations and, for that matter, the very existence of such long-distance signals, was just as characteristic of ultra-high-frequency propagation as is the sky wave with its attendant fading characteristics of high-frequency transmission.

The Wave is Bent in the Lower Atmosphere

Early in the program it became apparent that the signals were being propagated over the Boston-West Hartford path not through the agency of the ionosphere but by some phenomenon occurring in the lower atmosphere. This conclusion was strengthened by the discovery that signals were invariably weaker during the earlier hours of the afternoon than at any other time of the day. Then, extremely strong signals were had during periods when conditions in the ionosphere were known to be unfavorable for very-high-frequency propagation. Further, a relationship between the signal variation and changes in local weather conditions was almost immediately established.

The examination of the recordings has involved the preparation of mean values for signal level for each day and for a six-hour period during the early morning. These values of signal level have then been studied in connection with recordings of temperature and humidity conditions in the lower atmosphere taken on meteorological airplane sounding flights made each morning at Mitchel Field, Long Island, and East Boston, Mass.

These meteorological data are taken usually at 5:00 a.m. Unfortunately they do not always reveal accurately the conditions existing in the lower atmosphere over the path itself, since Mitchel Field is approximately 90 miles to the southwest of West Hartford while East Boston is approximately 100 miles to the northeast. Nevertheless, the availability of atmospheric soundings from the two points has made it possible to distinguish those mornings on which atmospheric conditions were so transient as to handicap any attempt at correlation.

This study of atmospheric conditions and prevailing signal levels has served to establish that the most effective bending of the waves and the resulting high signal level coincides with the existence of what we shall call a positive temperature gradient in the lower atmosphere. This condition is one in which the temperature of the atmosphere drops with increase in height above the earth's surface to a lesser degree than that considered to be normal. The work has shown that such a temperature condition is much more effective in producing the necessary bending of the waves if it is accompanied by a high order of specific humidity.

Over this particular path, the atmospheric conditions of greatest importance have been found to be those between the surface and 6000 feet.

Seasonal Variations

Examination of the continuous record for the four seasons of the year (Fig. 11) shows that during the winter and early spring the signal level is relatively low, with small day-to-day changes. This condition is believed to result from the prevalence of relatively dry air in which the temperature usually drops off sharply during the first 1500 feet of altitude. With the coming of summer, the signal shows a sharp and steady increase to the end of June, this resulting from a similarly steady increase in the specific humidity and the trend towards a temperature condition, particularly at night, giving a sharp increase in the temperature of the atmosphere from the surface to approximately 2000 feet. The summer period, as late as the end of August, shows consistently high signal levels with the exception of two or three occasions when abnormally dry "polar"-type air masses prevail. With the coming of autumn the signals often show extreme variation from day to day. These variations follow closely the vigorous changes in the water-vapor content of different air masses which characterise the autumn season. At this time of the year it is normal to have an extremely moist summer-type air mass on one day with a dry winter-type air mass immediately following it. With the coming of winter, the summer-type air masses gradually disappear and by December the signal resumes its normal winter level with the characteristically small day-to-day variations.

Diurnal Variations

We have considered, so far, only mean values of signal level for each day. Turning now to the variation in signal level during the course of each day, we find further significant features. The diagram giving average hourly signal intensities for the four seasons (also on Fig. 11) shows clearly the manner in which the signal drops to its lowest value during the early hours of the afternoon. The daily change in signal during winter is of a low order, this being considered to result from the small change throughout the winter day in the temperature gradient in the lower atmosphere. The spring and autumn diurnal characteristic is seen to give a much higher signal during the night, with the period of maximum signal occurring earlier. The summer characteristic reveals a period of maximum signals at approximately 1:30 a.m., signals dropping sharply immediately after sunrise. The steep increase in signal level during the course of the afternoon is undoubtedly related to the rapid development during those hours of the characteristic summer night-time positive temperature gradient caused by the cooling of the surface air. Perhaps the

most significant point of all is that the signal level during the summer afternoon is not greatly in excess of that observed in the cooler months. This is of particular interest since meteorological observation indicates that the specific humidity of the summer air does not undergo any marked change during the course of the day. From this one fact it is possible to conclude that while a higher order of water-vapor content is required to give appreciable bending of these ultra-high-frequency waves, the bending is greatly hampered by the absence of a positive temperature gradient.

Further diagrams (Figs. 12 and 13) are typical examples of studies made in the process of establishing a correlation between variations in signal level and variations in the order of temperature gradient in the lower atmosphere.

Hartford-Boston Amateur Communication

Before terminating the discussion of 60-mc. waves, we shall outline a further phase of the program involving daily observation of signals from low-lying amateur stations in the Boston area. The path over which these signals must travel can be considered as a trajectory having a radius of 65% of the earth's radius. As many as four optical horizons are involved. Further, most of the amateur stations operate with power inputs not in excess of 50 watts. Daily schedules with such stations have shwon that they are capable of covering the Boston-Hartford path on substantially any evening during the year. The winter signals, however, are usually of a low order and subject to extremely severe fading except under conditions when a tropical air mass, overrunning a polar air mass, provides a particularly steep positive temperature gradient. During the summer these amateur signals rise to high levels even during stable weather conditions, and reliable night-time communication becomes a possibility. During the more favorable summer nights these amateur signals frequently provide a field strength estimated to be of the order of 300 microvolts per meter and, under these circumstances, the Boston amateur stations are capable of producing severe interference with signals from local amateur stations operating within a few miles of the receiver. On frequent occasions during the summer, with a low-elevation positive temperature gradient prevailing, the amateur signals have been observed at considerably greater strength than that of the signals from the higher-powered and more-elevated station at the Blue Hill Observatory. The normal period of reversal of weather conditions in New England is such that these periods of extraordinarily low signal attenuation are prone to occur at intervals of about five days. On most of these occasions it is not only possible to communicate between West Hartford and Boston but also between Hartford and the New York area -- the latter path traversing several ridges of hills some 600 feet higher than the West Hartford station and, as a result, some seven optical horizons.

Work on 112 and 224 Mc.

We shall turn now to observations made on frequencies other than 60 mc. During 1935, morning and evening schedules were maintained over the West Hartford-Blue Hill Observatory path on 112 mc. (about 2-1/2 meters). Every endeavor was made to maintain a similar order of effectiveness in the transmission and reception equipment. These comparisons indicated that while communication could be maintained on most occasions with somewhat similar effectiveness on both frequencies, the 60-mc. wave was, almost invariably, the more effective. Similar transmission and reception equipment was also installed to operate on a frequency of 224 mc. (about 1-1/4 meters). Satisfactory communication was established over various optical paths embracing distances up to 60 miles, but repeated attempts to establish communication between West Hartford and Blue Hills have been met with failure. These observations on 112 and 224 mc. have led to the conclusion that the bending of ultra-high-frequency waves in the lower atmosphere becomes less as the frequency increases and that the higher ultra-high frequencies cannot be expected to provide communication over very long indirect paths as

effective as that possible on the frequencies between 60 and 30 mc.

On Higher Frequencies the Air-Wave Bending Decreases

This contention is firmly substantiated by the most recent phase of this program of ultra-high-frequency observations. During the last several weeks continuous recordings have been made at West Hartford of the signals from the newly-erected experimental station W1XER operating on 41 mc. and located at Squantam, near Boston. The transmitter is located close to the sea coast. A simple dipole antenna approximately 250 feet above sea level is excited from a transmitter rated at 500 watts output. The signal level received from this transmitter in West Hartford has been compared to that received from the 20-watt transmitter W1XAC operating at the same location on 61.5 mc. and it has been found that the field strength from the lower-frequency transmitter is considerably stronger than the power difference between the two transmitters would lead one to anticipate. Using a simple dipole receiving antenna 30 feet above ground it has been possible to obtain an input to the receiver of 150 microvolts from the 41-mc. signal on occasions when the 61.5-mc. signal was essentially inaudible.

Further observations of the 41-mc. signal have been made at locations in residential West Hartford not over 100 feet above sea level and it has been observed that the signal level under normal stable weather conditions is sufficient to provide an input to the receiver from a simple dipole antenna of between 50 and 100 microvolts.

The chief conclusion to be reached from these various observations is that stratification of the lower atmosphere is responsible for an order of bending of ultra-high-frequency waves considerably greater than that previously believed to occur. They would further indicate that stratification sufficient to allow communication between low-powered stations separated by three or more horizons occurs with such frequency that we are obliged to consider the phenomenon thoroughly normal and by no means a freak.

It has been suggested that the Hartford-Boston path is in some way subject to exceptional atmospheric conditions. Meteorological studies have shown, however, that similar conditions prevail over most of the country and, indeed, that in certain localities still more favorable atmospheric conditions may well exist. This circumstance suggests the thought that an additional complication may soon be added to problems of allocating channels in the ultra-high-frequency spectrum: a study of prevailing conditions in the lower atmosphere at each locality may well become an important requirement.

Ignition Interference

To return to the general subject of ultra-high-frequency operation and to consider now the various technical problems and their partial solution, it might be mentioned that the chief deterrent to satisfactory reception on the ultra-high frequencies is man-made electrical noise. The chief offender in this respect is the ignition system of automobiles which transmit highly-damped waves, of a type now commonly forbidden by law. Their range is short but whenever an automobile approaches the ultra-high-frequency receiving station it creates havoc. This type of interference is particularly severe on the frequencies between 60 and 30 mc. but is much less noticeable on frequencies above 60 mc. As has been previously mentioned to-day, there now exists an amateur development in the form of a noise silencer particularly suited for the reduction of noises of the type produced by automobile ignition systems. This type of noise silencer is being used with excellent success by amateur ultra-high-frequency workers but because such devices are necessarily complex and since they may be operated only in conjunction with a relatively advanced type of receiver, their use is by no means general. The super-regenerative receiver, to some degree, owes its

great popularity to its inherent ability to discriminate against highly-damped waves, and the use of super-regeneration either in a simple receiver or in the final detector of a superheterodyne provides one means of reducing this type of interference.

Relief is Needed

Of course, it is much more logical to attack such problems at the source. It is our belief that the ultra-high-frequency world is greatly in need of relief in this respect, and that it is imperative before there can be any widespread adoption of ultra-high-frequency waves for commercial services. As early as September, 1933, the League brought this matter to the attention of the Commission and of the automobile industry and has worked earnestly to secure some relief, but so far without success except for the dawning general realization that it is a problem about which something must be done. Extensive communication with leaders in the automobile industry and with manufacturers of automobile ignition equipment has led to studies on their part of the technical considerations involved in non-interfering ignition apparatus. However, a much more vigorous and widespread action is essential. It is not alone the amateurs who are incommoded. The police and other users of ultra-high-frequency suffer similarly. There can be no widespread adoption of the ultra-high frequencies, as for popular television, until some solution is found. A start in the right direction would be the equipping of all newly-manufactured automobiles with suppressors. This, of course, would not solve the situation until all existing unequipped automobiles had been retired through obsolescence but it would at least be a beginning. We would earnestly urge the Commission to take this question under study as one of the major technical problems involved in the successful development of ultra-high-frequency services.

V -- FUTURE AMATEUR NEEDS IN ULTRA-HIGH FREQUENCIES

We would first like to discuss our 60-megacycle band in its relation to television. It has been suggested, by some of those interested in television, that the amateur allocation from 56 to 60 megacycles is a painful interruption in a continuity of frequencies useful in the future of that service. We would like to remark that we regard this band as an indissoluble part of the amateur family and that we can not contemplate either its cancellation or its removal.

In this country it has been assigned exclusively to amateurs since 1924, it has been extensively occupied by amateurs for many years, and there are to-day many thousands of amateurs possessing transmitting and receiving equipment especially built for this band. The amateur allocation, as we have previously emphasized, is a harmonic family. We amateurs commonly use the same antennas, excited at different harmonics, to operate in the various bands. Many of us now possess crystal-controlled transmitters for this band, using crystals that are also suitable for our 14,000-kilocycle band, doubling once to reach our 28,000-kilocycle band and twice to reach this one. This is a perfectly logical arrangement, sound from an engineering standpoint, that would not be possible were the band out of harmonic relationship to the others.

We take note, of course, that at this hearing most of the spokesmen for television have recognized our occupancy of this band and its importance to the amateur service. We think this a far-sighted policy on their part, for which we are duly grateful. We have had no frequency conflicts with other services and we hope we shall never have any with television.

The Suitability of Frequencies for Television

It seems to us that there is doubt about the suitability of 45 megacycles, or even of 55 megacycles, for the television service of the future. It would seem to be a fundamental principle of that service that the frequencies assigned be of an optical or quasi-optical characteristic, their range confined substantially to the visible horizon. This is necessary in order that frequencies may be repeated across the country to provide a nationwide service with a limited number of channels. We think our earlier evidence may show that the frequencies of this order are unsuited to such use, as they are at times responsive to ionosphere bending and capable of reception in great strength at a distance of many hundreds of miles. Naturally such reception would be ruinous and would defeat the aim of the discussed allocation plan for television. Even the air-wave bending of frequencies of the order of 40 megacycles is capable of delivering signals of considerable strength at a distance of over 100 miles, from transmitters of low power. The frequencies chosen should be those that are least responsive to sky-wave bending, and that suffer a minimum of air-wave bending. Fortunately, the higher the frequency the less this air-wave bending. From our experience in this field we would like to suggest that the beginning frequency for television might well be 60 megacycles, and that a proper assignment for that service might be from 60 to 112 megacycles -- which, incidentally, would provide a few more channels than has previously been discussed.

Ignition Interference is Less Above 60 Mc.

Another aspect that must be considered is susceptibility to interference from electrical equipment, especially automobile ignition systems.

While amateurs employ special types of receivers and have developed circuits for conventional superheterodyne receivers that mitigate and practically eliminate the interferences of this kind on the 56-megacycle band, this problem still remains in far more aggravated form for television reception, except possibly in the areas of extremely strong field strengths. The automotive ignition type of interference naturally peaks on this band of frequencies, because of the characteristics of the source. Its removal by special receiver circuits, while causing no appreciable loss to voice or telegraph reception in amateur communication, would hardly be tolerable to much more critical visual reception. This type of interference decreases rapidly at frequencies above 60 megacycles and would accordingly approach negligibility as a problem to television on these higher frequencies.

Amateur Needs in the U.H.F. Field

Referring now to our own future in this ultra-high frequency field, we believe that the amateur-experimenter has richly justified the national policy of assigning to him modest test slices an octave apart through the high-frequency spectrum. We are intensely interested in the ultra-high frequencies, we believe that we have already demonstrated our ability to make contributions to that art, and we believe that we are entitled to similar allocations as a continuation of our harmonic family, so that similar specimens of the spectrum may be available throughout the ultra-high-frequency region for the use of eager and inquiring experimenters.

Referring to the chart shown you a short while ago, we would like to recall to you that for several years back we have had on file with the Commission a formal request that there be assigned to amateur radio the frequency bands from 112 to 120 megacycles, 224 to 240 megacycles, and 448 to 480 megacycles, and so on to as high a frequency as definite allocation is carried. We should perhaps explain that at a fixed percentage of instability, these increasing widths in kilocycles accommodate the same number of stations, and that the suggested figures are of the same practical width as the existing amateur bands from 28 to 30 megacycles, and from 56 to 60 megacycles.

Jointly with all other experimental stations we are now enjoying the right to share in the experimental use of all frequencies above 110 megacycles. This is a temporary arrangement, pending specific allocation to services by the Commission.

We now renew our request that the Commission make a definite allocation to amateur radio of further high-frequency bands in harmonic relation to the existing amateur high frequencies. It is likely that different characteristics will eventually be discovered for these different bands of frequencies and it is certain that the technique necessary to master them will vary from octave to octave. The needs of the amateur institution require such allocations and we believe we have demonstrated that it is reasonable to expect continuing results to the art from such allocations to amateurs.

ANNEX

EXHIBIT I, BEING A PARTIAL CHRONOLOGICAL RECORD OF EMERGENCY COMMUNICATION SERVICE PERFORMED BY UNITED STATES RADIO AMATEURS

During the period from March 24th to 31st, 1913, amateur stations at the University of Michigan at Ann Arbor, and at Ohio State University, in conjunction with numerous individual amateurs in and around the region, successfully bridged the communications gap surrounding a large isolated area left by a severe wind storm in the middle west.

During a tropical storm which swept lower Texas in middle September, 1919, with destruction of Port Aransas and loss of life and property at Corpus Christi, Clifford W. Vick of Houston received newspaper dispatches and general information to an extent greater than any other source, despite the fact that the transmitting ban had not yet been lifted.

On the night of May 14, 1921, when auroral disturbances completely disrupted wire service, Hiram Percy Maxim, 1AW, secured AP news direct from New York for the "Hartford Courant".

In late February, 1922, an ice storm and blizzard completely isolated Minneapolis and St. Paul from the outer world. 9XI, the University of Minnesota, 9ZT and 9AJP established communication with amateurs in Indianapolis, Chicago and other points and handled press and official emergency traffic continuously for forty hours.

On November 4, 1922, a snow storm covered Wyoming and Colorado to a depth of fifteen feet. Two trains of the C. & S.R.R. were blocked in the storm. The Union Pacific was also tied up. Norman R. Hood, 7ZO, of Caspar, Wyo., handled relief traffic for both systems as well as the press for nearly forty hours with amateur stations in Denver and Kansas City, saving several trains with their crews and live cargo.

Wire communication in the upper Mississippi valley was destroyed by storm on March 12, 1923. 9ZN, Chicago, organized a relay net into the stricken area with the assistance of 9APW, 9AZA, 9BHD, and 9ALG. The principal work done was in handling communications for the C.G.W. railroad.

The Arkansas river flood in the summer of 1923 wiped out all communications between Tulsa and Sand Springs, Okla. 5XBF, assisted by 5GJ, contacted 5GA, 5SG and 5WX in Tulsa and handled press, personal and official messages for three days and nights.

In October, 1923, the A.R.R.L. considered plans for organizing a railroad emergency committee. By 1924 this had been accomplished, and test drills over the Pennsylvania railroad begun.

On November 25, 1923, railroad communication out of Burlington, Vt., was tied up as a result of a heavy storm. 1ARY, the University of Vermont station, was called upon for aid, and contacted c2CG in Montreal, with whom messages were exchanged until wire lines had been repaired.

A bad storm in Neah Bay, Wash., the night of December 8, 1923, brought disaster to canneries in that area. Relief was brought by messages from 7IP through 7GI, of Spokane, resulting in the saving of considerable property.

From February 3 to 5, 1924, a blizzard swept the northern half of

the United States, paralyzing wire communication in the middle west and isolating many large cities. Hundreds of amateur stations were active, handling messages for the railroads, press, officials, and individuals, saving numerous lives and much valuable property.

On February 19, 1924, sleet caused a total interruption of the West Penn Power Co.'s service in Pennsylvania. 8WR, his own station out of operation, erected an antenna for 8XAP and got it on the air, handling messages for two days until wire repairs had been made.

On May 17-18, 1924, test messages were sent over the newly organized Pennsylvania railroad net, with 45 out of 50 messages correctly delivered from four regional headquarters to the main division points. This test began what was to be a heroic record of actual emergency work during the next two years.

In the winter of 1924 a number of ice-locked vessels plying the Great Lakes in the vicinity of Duluth, Minn., were supplied communications service through A. L. Bergtold, 9DOE, and amateur stations with whom he was in contact.

In 1924 the Commissioner of Navigation announced that his office would permit amateur stations to use their own discretion in times of emergency insofar as observance of regulations was concerned.

The Florida hurricane of 1926 wrecked Miami, Pensacola and other cities. 4KJ and 4HZ quickly got on the air with emergency battery-powered apparatus, sending a message to the governor of Florida asking for aid and outlining the most pressing needs as the first traffic. During the several days before wire service was rescued, these and dozens of other stations stayed constantly on watch handling hundreds of messages and many words of press.

On February 16, 1927, heavy rains finally washed out wire communications around San Diego. During the lapse while repairs were being made, all communications were handled by amateur radio. 6DAU, 6FP, and a number of other amateur stations handled press and emergency traffic.

Areas in Arkansas, Mississippi and Louisiana were flooded in 1927. 5SW transmitted the first news of the disaster to the outer world. With 5ABI, 5QJ, 5UK and a number of other stations, traffic for the military, the Red Cross, officials, the press and individuals was handled for three days.

In June, 1927, a cloudburst in northeastern Kentucky caused a flood, resulting in the loss of several lives and considerable property. 9DVT was the only means of communication for the isolated region for many days, finally causing the arrival of relief after more than a week of impassable roads and tracks.

November 4, 1927, found large areas of New England isolated by flood, as a result of a tropical storm sweeping the entire Atlantic coast. Many thousands of messages of all descriptions were handled by dozens of stations who were literally in the emergency area.

The Santa Paula (California) flood of 1928 followed a dam break, and there was no preliminary warning. 6BYQ transmitted almost immediately the urgent messages of the Red Cross, however, and along with 6DCJ stayed home from school for three days to handle 50 official messages and numerous press reports and messages for individuals.

The second Florida hurricane, in 1928, found amateurs forewarned and mobilized. 4AFC at West Palm Beach, operated by Ralph Hollis and Forrest Dana, established the sole communications link for three days,

starting all relief machinery, handling all telegraph communications, while in the meantime their homes and property were being swept away.

Sleet and snow brought down miles of telephone and telegraph lines in western and northern New York state on December 18, 1929. The Niagara Falls Power Co., requested W8OA to establish emergency communication with Lockport. W8ADE, W8OA, W8AFM kept their respective cities in communication with outer points for the Power Co., A.T. & T., Lackawanna railroad, and the N.Y. Power and Light Corp.

On November 19, 1930, a severe sleet storm and blizzard brought down all wires between Sutherland and North Platte, Neb. On the 20th, W9BBS of North Platte was requested by the Union Pacific railway to establish communication to the west. Traffic was handled with W9EXP for 22 hours before wire lines were repaired; 100 messages totalling 3100 words. Postal Telegraph traffic was also handled.

The same blizzard hit North Dakota, with lines down between Jamestown and Fargo. W9CBM and W9DGS handled traffic for the Northern Pacific railroad, the telephone companies, and the press.

A snowstorm on March 16 and 17, 1931, isolated Salisbury, Md., from the outer world. W3VJ furnished the city with its only means of rapid communication.

March, 1932, found the Atlantic seaboard and middle western states in the throes of severe snow, sleet and wind storms on several occasions. In Illinois, important emergency traffic was handled for the Illinois Power Co., on March 2nd. Cumberland valley and western Maryland found itself isolated by a blizzard on March 6th, when telephone, telegraph and teletype failed and amateur radio was the sole means of communication. Numerous localities in Virginia, Maryland and New York were in the same situation.

The Guadelupe river rose 45 feet July 1, 1932, and sent a wall of water from northeast of San Antonio, Texas, isolating several towns in the summer resort country. The emergency station rigged by four volunteer operators handled 136 distress messages, many of them Western Union telegrams, others for government and relief officials, in three days continuous watch.

One of the worst storms in the history of California began September 30, 1932, releasing a flood from high up in the Sierras through the Caliente canyon, killing many people and causing two million dollars damage. An expedition of radio amateurs from Bakersfield was led by the California Highway Patrol to the stricken area and conducted relief communications for a day and a night.

The California earthquake of March 10, 1933, found dozens of amateur stations in the earthquake area and hundreds outside of it on continuous watch for from one to three days, cooperating with all relief agencies operating within the zone and handling the rapid communications almost exclusively.

August 22, 1933, found the Delmarva peninsula submerged and wire communications as well as transport routes obliterated. W3CQS, Salisbury, Md., and W3BAK, Laurel, Del., provided the sole communications outside the region, working with officials, the press, and wire services.

At the same time the Tidewater section of Virginia was struck hard, an eighty mile gale costing the lives of 15 and $10,000,000 damage in the Norfolk region. Amateur operation again provided the sole contact until wire services were renewed.

A tropical hurricane struck Florida September 3, 1933, with all communications wiped out by the next morning. The Florida emergency net, a group of amateur stations constantly on watch for such emergencies during the hurricane season, functioned in bringing full reports in and out of the zone.

A similar hurricane struck Texas September 5th, taking the lives of 26 and wreaking $20,000,000 damage in the eastern Rio Grande valley. Amateurs rescued a marooned railroad train and handled quantities of emergency traffic.

The telephone company could not render service to its patrons in New Hampshire when power lines failed on April 8, 1932, so officials called on amateur radio for assistance, primarily to direct the repair work.

Wallace and Kellogg, Idaho, were isolated for six days in December, 1933, as a consequence of floods; the services of two amateur radiotelephone stations were employed in bridging the intelligence gap. To aid in this work, a complete amateur station and Carl Johnson, its operator, was flown into Wallace from Spokane.

A raging storm on the Oregon-Washington coast in middle December, leaving in its wake ships torn from piers, the sea rushing over dikes and highways, a steamer blown ashore, and all communications disrupted, found the Army Amateur Radio System on the job, with traffic and press handled nightly until December 19th.

On the night of February 25, 1934, Winston-Salem, N. C., was visited by the worst sleet and ice storm in the memory of its oldest inhabitants. Amateur emergency work went on for upwards of forty hours, more than 100 messages being handled for railroad, telephone, telegraph and power companies.

About 2:30 a.m., April 4, 1934, the Washita River went rampaging down its valley, sweeping everything away before it. Seventeen persons were killed, and the property damage ran into millions. Communications were cut off from Hammon, Leedy, Butler, and Quartermaster. W5ACI and W5BBH hauled a portable station 25 miles to the stricken area, and handled hundreds of messages during the next two days, principally relief traffic.

Tillamook Rock Light station, off the mouth of the Columbia River, was badly damaged in a storm on October 21, 1934. The telephone cable was wrecked, but Henry Jenkins, W7DIZ, assistant keeper, ingeniously improvised a radio transmitter from an old broadcast receiver, and successfully contacted the mainland and secured badly needed assistance.

Amateurs aided in the search for a lost American Airlines plane which crashed in the Adirondacks on December 28, 1934, a party of amateurs from Schenectady with portable equipment exploring the mountainous region and providing needed communication.

On January 21, 1935, a flood disaster in Arkansas, Mississippi and Tennessee necessitated a constant watch on behalf of the Red Cross and other relief agencies on the part of amateur radio.

On January 23rd the eastern shore of Maryland, Delaware and Virginia was visited by the most severe sleet storm in twenty years. With practically all communications and power wires down, amateur stations, primarily of the Naval Communications Reserve, maintained regular watches for from two to five days, handling all varieties of emergency traffic.

A sleet and snow storm on March 4th and 5th completely cut off all communication from Superior, Wis., and Duluth, Minn. One amateur, erect-

ing an emergency antenna, was instantly on the job. Others, responding to a plea from a broadcasting station, quickly followed. The Northwestern Bell Telephone Co., Western Union, Postal Telegraph, a power company, brokerage houses and individuals were the chief users of these facilities.

The flood that inundated Colorado and Nebraska in late May and early June of 1935 saw dozens of amateurs in these states working with the National Guard, police, press, the railroads, the U.S. Army, the Red Cross, power companies, telephone companies, Western Union and Postal Telegraph, as well as local relief officials.

On July 8th, the Finger Lakes region of New York state was severely flooded, resulting in the loss of about 40 lives and property damage of over $5,000,000. Ithaca amateurs, in the center of the stricken area, worked with local relief agencies and outside amateurs, relaying many important messages from and to areas without other means of communication.

During no less than three hurricanes in Florida in September and November, 1935, amateurs served as communications links in areas isolated except for amateur radio, handling news items, relief instructions, and orders for medical supplies, etc.

An ice storm in central Georgia in late December, 1935, produced $2,000,000 damage and wrecked all wire communications. An emergency amateur station, W4APX, set up in the courthouse, kept 5000 people in touch with the outside for three days.

Perhaps one thousand amateur stations east of the Mississippi River participated in the flood emergency work of March, 1936. At least 400 stations were active in the primary emergency zone, which included 13 states. With a half million homeless and hundreds of thousands destitute, but 214 lives were lost, due primarily to effective emergency communication. Amateur stations represented the sole communications links with scores of points, principally in Pennsylvania, New York and New England.

Several hundred distress messages were handled by emergency amateur stations installed at Gainesville, Ga., when the tornado hit that place on April 6th. One station was carried in from Atlanta, another from Athens; others were locally assembled.

A special amateur network was provided through the American Radio Relay League for the Coast Guard's mobile emergency communications unit NRSA following the Tupelo, Miss., tornado on April 9, 1936. Assistance in locating injured and missing persons was given and contact with hospitals in other cities maintained.

ANNEX

EXHIBIT II, BEING RECENT STATEMENTS BY LEADERS IN AMERICAN PUBLIC LIFE CONCERNING VARIOUS ASPECTS OF AMATEUR RADIO

The President of the United States:

It is generally conceded that amateur radio is a great training school for the radio art and industry. It is most gratifying to note that more than forty-five thousand Americans devote much time daily to the study and practical application of radio communications. The liaison of the radio amateurs with the Army Signal Corps and with the Naval Communications Reserve, indicates that the Government fully appreciates the amateur radio operators and stands ready to encourage them in every possible manner.

The fact is that the future of radio depends to a large extent on the amateurs, for it is their initiative, enthusiasm and ingenuity that overcomes radio barriers and leads to new frontiers, putting new problems up to science.

Hon. Herbert Hoover, ex-President of the United States:

As you know, I have felt over these many years since the association (the American Radio Relay League) started that the amateurs were making a positive contribution to the development of radio. I recall with great pleasure the years of co-operation in which I was able to join with them. I trust the organization will continue to grow and to meet with continued success.

Major-General Malin Craig, U.S.A., Acting Secretary of War:

Through the medium of your organization I desire to express on behalf of the Army our appreciation of the valuable assistance rendered by many radio amateurs in the recent flood emergency. The voluntary emergency communication service furnished by them in the handling of messages for Army organizations engaged in relief work was of vital importance during periods when other means of communication had been disrupted.

The affiliation of the Army and the radio amateurs by means of the Army Amateur Radio System has proved to be a valuable asset to relief organizations when attempting to relieve distress in such emergencies. The radio amateurs can be proud of the fine service they performed.

Admiral W. H. Standley, U.S.N., Acting Secretary of the Navy:

A number of reports have been forwarded to the Navy Department by the Commandants of the Naval Districts in which disastrous floods occurred during the month of March. These reports praised very highly the emergency communication conducted by members of the Naval Communication Reserve who are also amateurs and operate their own amateur radio stations. Because of their dual status as communication reservists and amateurs, it is believed that you will be interested to learn of the excellent service which they performed while operating under the Red Cross Emergency Communication Plan published to the Service in June 1930.

The Navy Department has expressed its appreciation of the volunteer service so efficiently rendered to the individuals concerned via the Commandants of the Naval Districts and in our own publications. I want to take this opportunity of advising other amateurs through the medium of QST how much the Navy has appreciated the loyal co-operation of our American amateurs from the beginning of amateur radio to the present time.

I feel that the Navy Department can always call upon the American amateur for assistance and co-operation in time of local or national emergency.

Rear Admiral H. G. Hamlet, Commandant, U. S. Coast Guard:

I find great pleasure in extending to the American Radio Relay League my best felicitations on the occasion of its twentieth anniversary. The remarkable accomplishments of the American radio amateurs in furthering radio communication have been a valuable contribution to the public welfare. The United States Coast Guard in times of flood, earthquake, and other unfortunate visitations, has found the American amateurs a willing and useful ally giving that sort of co-operation which speaks for service. On such occasions, when communication with the rest of the country is interrupted and broken, the amateur, true to tradition and aspiring always to be of service, has come through with the news thereby assisting relief agencies intelligently to carry on operations. I wish the League the fullest measure of success and continued usefulness in its important field of endeavor.

Hon. H. Styles Bridges, Governor of the State of New Hampshire:

I welcome the opportunity to give wider circulation, through the official publication of your League, to the appreciation, which I voiced in New Hampshire at the time of our recent flood catastrophe, of the invaluable service rendered in the emergency by the amateur radio stations in the stricken localities.

Their readiness to aid matched their ability to serve and in many instances they were the only link between the flood-bound territory and the outer world. Here, in the State House, as we watched through the nights of the most critical time, members of your League, operating from the Executive Chambers, furnished us with information of the highest importance in regard to the rapidly changing conditions. It was a real triumph for amateur short wave radio operators.

Hon. Wilbur L. Cross, Governor of the State of Connecticut:

One of the redeeming features of the recent flood disaster was the very real co-operation exerted by all the various agencies, departments, and organizations who participated in the relief and rehabilitation work.

Certainly one of the most important volunteer activities was the prompt and efficient assistance rendered by the American Radio Relay League. The necessity for maintaining communication with the outside world at that time was vital. There is no way of determining the inconvenience and cost of carrying on in such a crisis without your aid.

As Governor of Connecticut, I want to thank you and the members of your League for your fine response to the situation.

Hon. Theodore Francis Green, Governor of the State of Rhode Island:

I am informed that during the flood emergency last March a number of amateur radio operators stood watches at their stations ready and waiting to be of service in the event of failure of established communications lines. A number of these operators were directly instrumental in the securing of relief aid and in the handling of personal messages on behalf of flood victims in other regions.

In Woonsocket and vicinity, amateur radio was of direct service to the people of Rhode Island. This state, in common with the other New England states, is appreciative of the advantages to the public welfare derived from the constant availability of this voluntary reserve corps of amateur operators, ready to serve in any emergency, and I congratulate your organization on the splendid work that you are doing in this field.

Hon. Herbert H. Lehman, Governor of the State of New York:

I note in the QST, a magazine devoted to the interests of the amateur radio operator, that amateurs in New York State received generous attention for their work during the spring flood. I was aware of their part in the flood relief activities of this spring but more thoroughly familiar with their work last summer when another flood was even more disastrous to communities in the southern tier section of the State.

The amateur radio operator frequently renders valuable service during major catastrophes when commercial methods of communication are still. Too often this valuable service is not recognized. I should like to here pay tribute to those amateur radio enthusiasts who did such fine work during the New York floods of last summer and this spring.

Dr. J. H. Dellinger, Chief of the Radio Section, National Bureau of Standards:

I extend my hearty congratulations to you and to the American Radio Relay League upon the completion of twenty years of fruitful activity in amateur radio. Your field is a conspicuous example of a hobby which has by-products of utilitarian value. I am happy to acknowledge the aid given by the amateurs on the advancement of radio science. The Bureau of Standards has called on the amateurs, through the League, for collaboration in a number of projects, and has always met a cordial and effective response.

I congratulate you not only on the splendid record which the League has made but also on the bright future of amateur radio. The amateurs have won a definite place for themselves in the scheme of things radio. This has been in large part accomplished through the organization of their activities in the American Radio Relay League, and this effective organization in turn has in large measure sprung from your leadership.

Dr. A. Hoyt Taylor, Superintendent, Radio Division, U. S. Naval Research Laboratory:

When the Naval Research Laboratory started its pioneer work in the high-frequency band in 1923, there were no naval ships or stations operating in this band except those using the old inter-Fleet sets on 125 and 150 meters. The receivers for this work were of very narrow range and not at all sensitive.

We therefore turned to our amateur friends for help in studying the properties of these new frequencies and in developing a suitable wave-propagation theory. Of course, during the war I came in contact with hun-

dreds of able amateurs, many of whom served under my command, and it was a very natural thing for me to turn to the amateur fraternity for help in the emergency of 1923.

From then on until 1927 and to a more limited extent since that time we have continued to use amateurs for assistance in this important work. The responses to our original request were extremely gratifying and I am frank to say that without the assistance of the amateurs the high-frequency program in the Navy would be very much behind what it is to-day. I shall never cease to be grateful for this willing assistance and shall never forget the many friends I made as a result of these contacts.

Of course, as time went on more and more high-frequency contacts were possible within our own Service so that the necessity for relying so heavily on the amateurs gradually went out of the picture. However, if similar conditions were to arise to-day I should not hesitate to again call on the amateurs for active co-operation with the absolute certainty that I would get the same hearty and cordial response. You may be sure that the American Radio Relay League and the amateurs of the United States have a very special place in the regard of all the members of the Naval Research Laboratory staff who have had to do with such contacts.

<u>Hon. Clarence Dill, former United States Senator from Washington:</u>

The millions who enjoy radio and are benefitted by its many services to the American family have no conception of the work that amateurs have done during the past twenty years for the development of radio into its present form.

<u>Hon. Eugene O. Sykes, former Chairman of the Federal Radio Commission:</u>

Ever since the creation of the Federal Radio Commission in 1927, it has been my privilege and pleasure as a member of that body to encourage the splendid growth of amateur radio and to appreciate the outstanding contributions to the radio art which originated with amateurs.

This Government has taken the lead among the nations of the world in fostering and developing amateur radio, and your co-operative response has more than justified this policy.

<u>Prof. A. E. Kennelly, President, Union Radio Scientifique Internationale:</u>

It is unnecessary for me to mention the great debt of thanks that the world owes to the past work of radio amateurs, in discovering and developing the possibilities of short-wave radio communication, now so much used in industrial radiotelegraphy. The history of amateur radio during the past twenty years is also closely interwoven with much valuable volunteer work in emergencies of all kinds all over the world. The radio amateur has often given valuable aid under circumstances where other means of communication were unattainable.

Commencing in the spring of 1914, with a small group of enthusiastic young amateurs, using short-range spark coils, the A.R.R.L. has steadily advanced in numbers, equipment and experience, until to-day the total exceeds, I believe, 60,000.

In our childhood, we read of fairies, witches, and other supernatural folk careering a broomstick over the skies. The A.R.R.L. has outrealized those nursery tales with nothing but an antenna as a vestige of the broom fancy, for the radio amateur actually launches his personality into the upper air beneath the layered ionosphere almost at light speed,

and calls upon his friends, perhaps half-way around the world -- friends whose language he may not know, and whom he may never be able to meet face to face -- to close the circuit of his thought.

The messages our radio amateurs exchange are bright with greeting, sympathy, and good cheer. The radio amateur language is highly distinctive, being mostly basic English interlarded with many international code-letter groups and abbreviations, more euphonious when transmitted than when vocalized. It sounds cheerily in buzzing dots and dashes through the head-phones of the listening amateur. QST is its journal and its theme is 73. What an army of goodwill and international amity are the world's radio amateurs! Their whisperings over all the oceans make for peace. So long as the amateurs are allowed to talk to each other freely, the world's peace is assured. Only with war and violence is the amateur's voice hushed.

We all hope that in the next twenty years, these knights of the joyous venture may continue their happy and helpful service to mankind, utilizing the ionosphere which radio science ever seeks to explore and understand. As in the past, we must all endeavor to make their useful influence realized internationally; so that modestly-adequate channels may be reserved for their activities in the great spectrum of radio-frequency allotments. Congratulations and success!

Mr. Robert E. Bondy, Director of Disaster Relief, American Red Cross:

The League and the Red Cross share some unique characteristics. We are both organized for unselfish public service. The length and breadth of the land is the sphere of our activity. Our regular activities go on day by day as a great foundation for the emergency activities that form a significant part of our programs.

The American Red Cross is given particular responsibility under its Congressional Charter for service in time of great disaster. With an average of over 80 disasters a year calling for Red Cross relief in this country, one of our most constant needs is that of prompt and adequate communication service.

For speed is the essence of effective disaster relief. With hurricanes and floods, warnings in advance of the disaster may be given. Programs of preparedness for the protection of lives and property are carried through by local Red Cross chapters when warning comes in time. Our experiences in the recent hurricanes of last year when compared with the hurricanes of several years ago, show very striking records of reduced loss of life and injuries because of early warning and preparedness measures taken in co-operation with the United States Weather Bureau and facilitated by amateur radio operators and other facilities available for communication purposes.

Once the disaster strikes, the Red Cross director on the field of the operations must maintain constant communication with his headquarters in Washington, St. Louis or San Francisco. His needs for personnel, his needs for supplies, and the amount of money needed for relief purposes must be promptly transmitted. Instructions go back to the director of the field operation from his headquarters' office. Failure to maintain communication may mean the serious hampering of relief and unnecessary suffering.

For these reasons, we urge our Red Cross Chapters -- and there is one in practically every county in the country -- to become acquainted with the amateur radio operators, interest them in becoming a part of the chapter disaster preparedness program and be prepared to work in close contact with the amateurs when disaster comes. There have been many situations

in which the service of amateurs has been invaluable and vital to successful relief. Our joint experience is enabling us to perfect this system of emergency communication and on the occasion of this Twentieth Anniversary of the American Radio Relay League we are happy to extend our thanks for these many services and to wish for the League and its great membership, an ever widening sphere of usefulness and service.

Dr. Walter G. Cady, Professor of Physics, Wesleyan University:

The American Radio Relay League deserves the admiration of all who are interested in radio, and this means the whole civilized world. Most of all, their achievements should be recognized by those who are in a position to understand the many constructive contributions that the League has made to the art of radio. We cannot forget the valuable inventions that have been made by League members, nor the men now occupying responsible positions who received their early training in the League. Outstanding, of course, is the pioneer work in the development of short-wave communication, which has become of great benefit to mankind as well as of enormous commercial importance.

In no other country have the amateurs played so vital a part in the development of radio. Working, as has frequently been the case, with slender means and meagre equipment, they offer striking proof of the old adage that "Necessity is the mother of Invention."

Mr. William S. Paley, President, Columbia Broadcasting System:

It is with a feeling of genuine appreciation that I congratulate the American Radio Relay League on the celebration of its twentieth anniversary. In the development of major industries as in the growth of sports, the amateur precedes the professional; and we in commercial broadcasting owe a debt of gratitude to you who first broke ground in the limitless field that is radio.

Our spheres of endeavor are separate but complementary, and the great progress that you have made in the past twenty years has been an inspiration to us. It is my hope that the next two decades in the relatively brief history of radio will witness developments of even larger import in our respective phases of radio.

Mr. M. H. Aylesworth, former President, National Broadcasting Co.:

You may well take pride in the fine work which the American Radio Relay League already has done in furthering the technical development of the art. As you know, many of the leading technical men of the National Broadcasting Company have been amateurs, and in fact many of them still are at heart. They join me in wishing you and your organization every future success.

Mr. Earl J. Johnson, General News Manager, United Press Associations:

Please convey to the membership of the American Radio Relay League our sincerest thanks for the excellent co-operation the amateur gave us during the recent floods which washed out many of our own communication links. The emergency was a critical one for us and we were delighted with the way members of your League came through with reports from areas where we were temporarily without telegraphic communications.

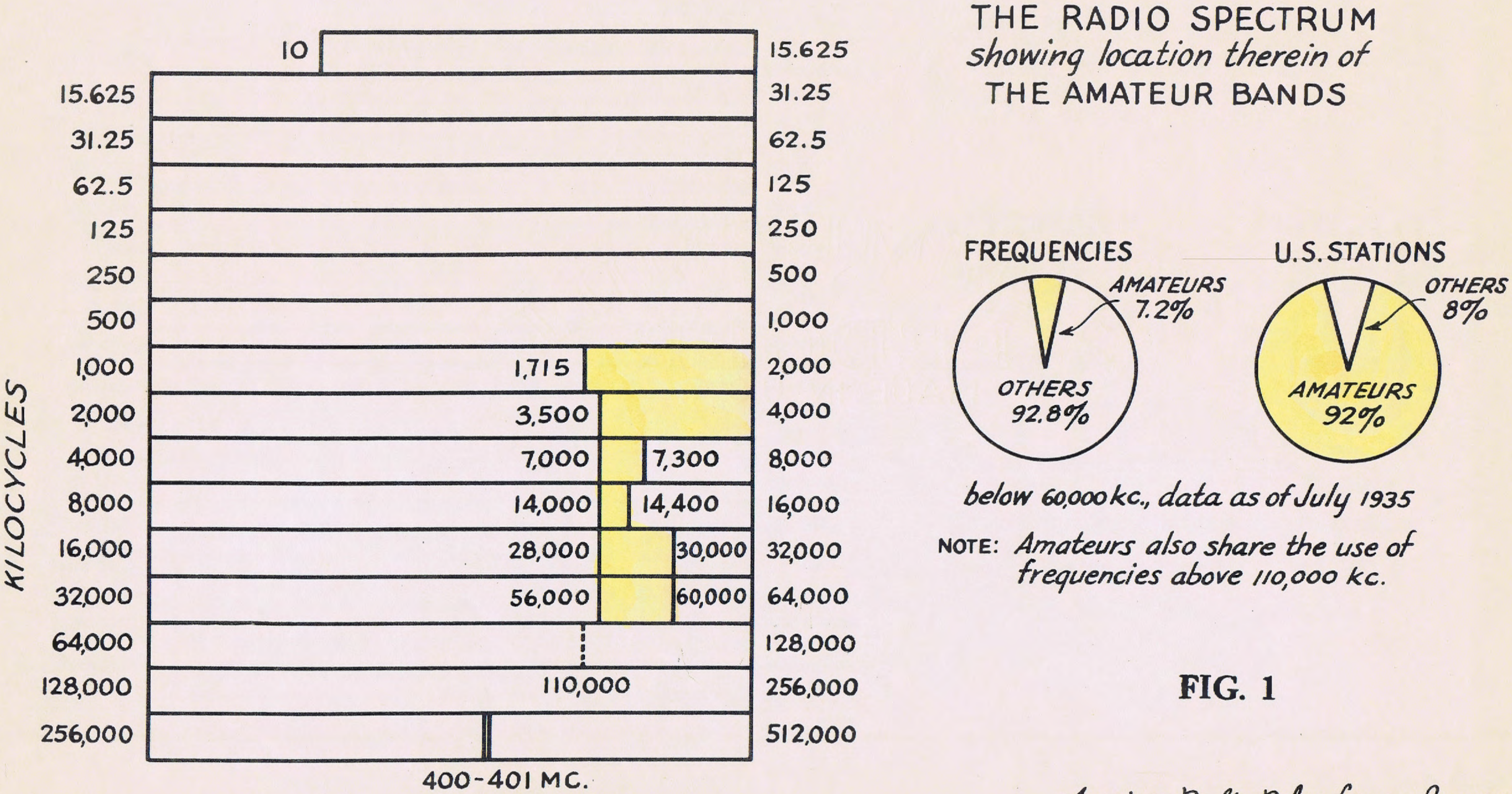


FIG. 1

American Radio Relay League - June 1936

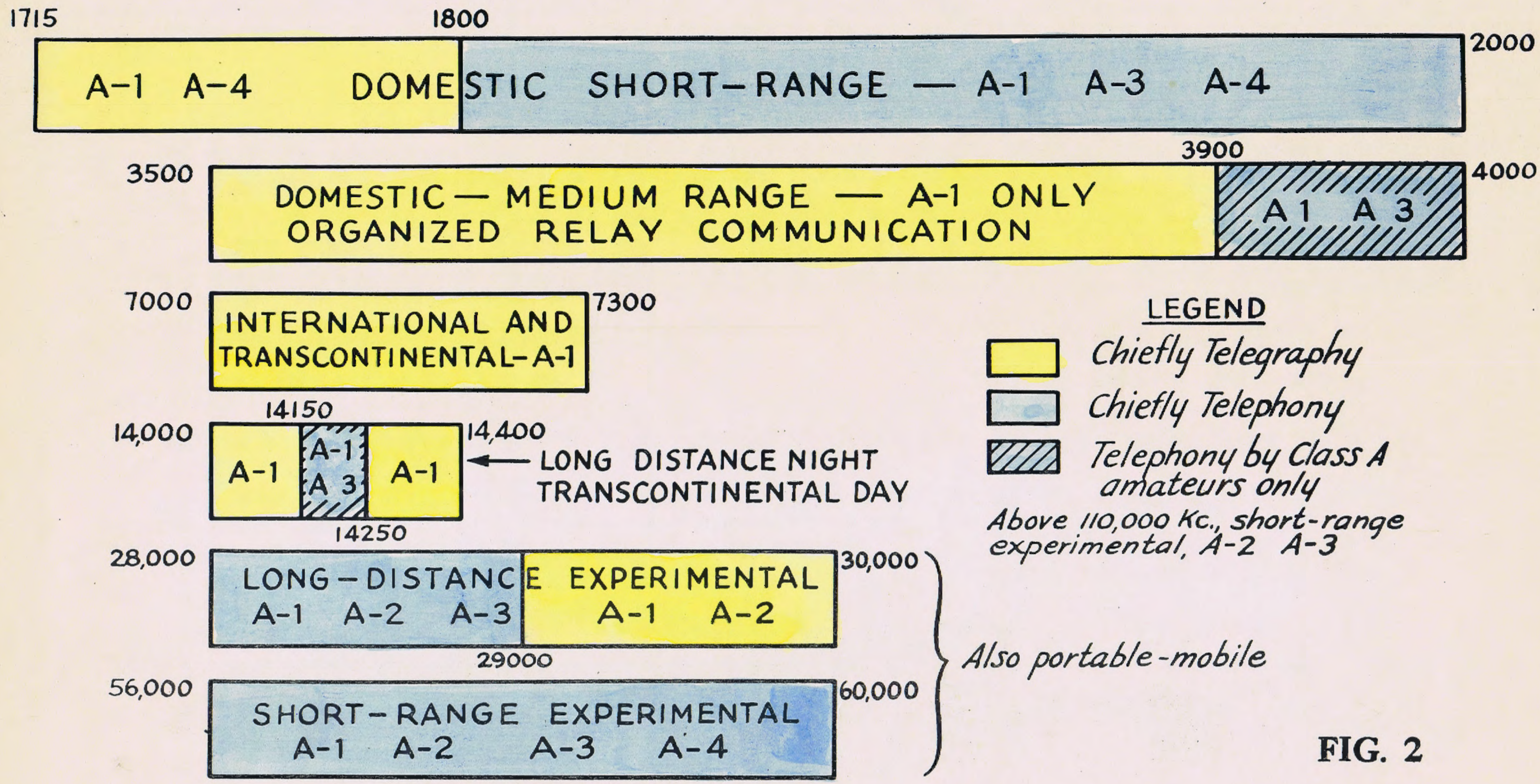
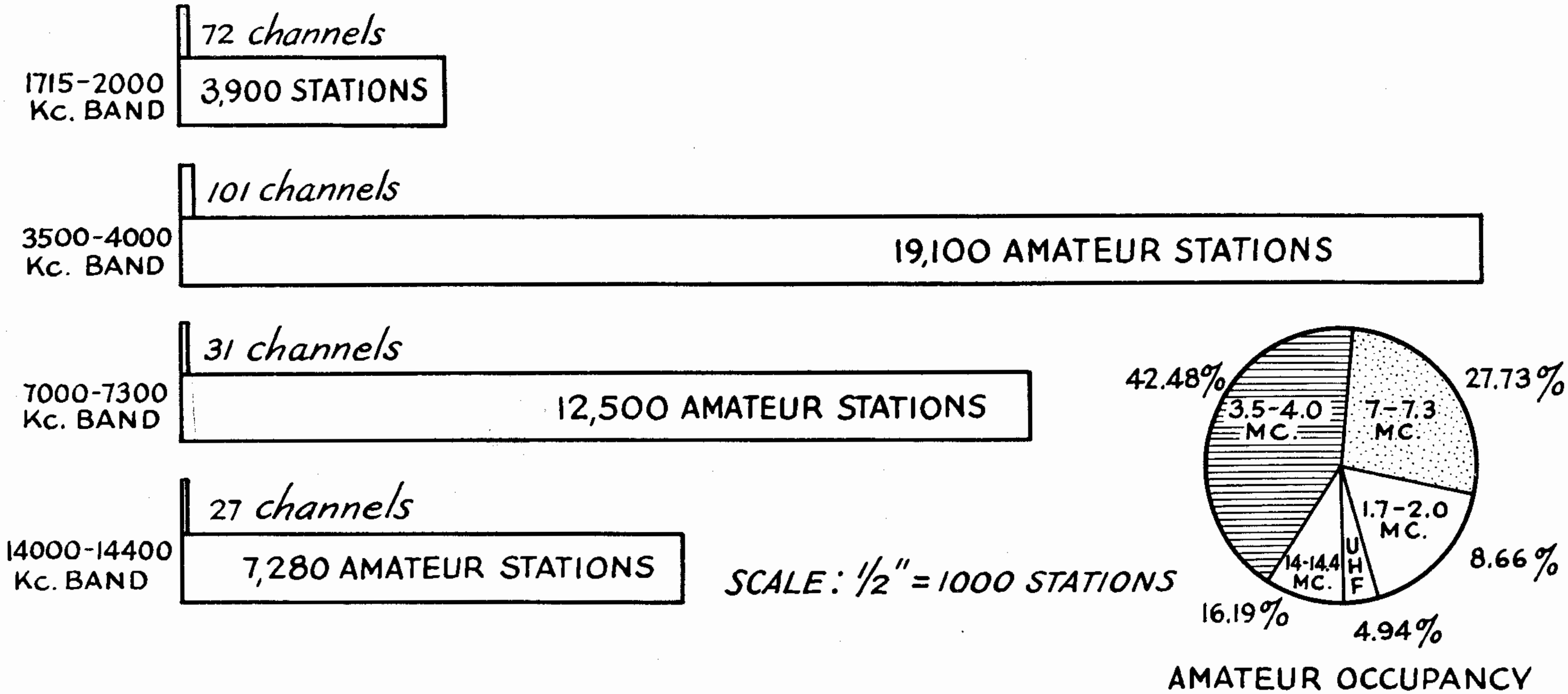


FIG. 2

EMPLOYMENT OF THE AMATEUR BANDS

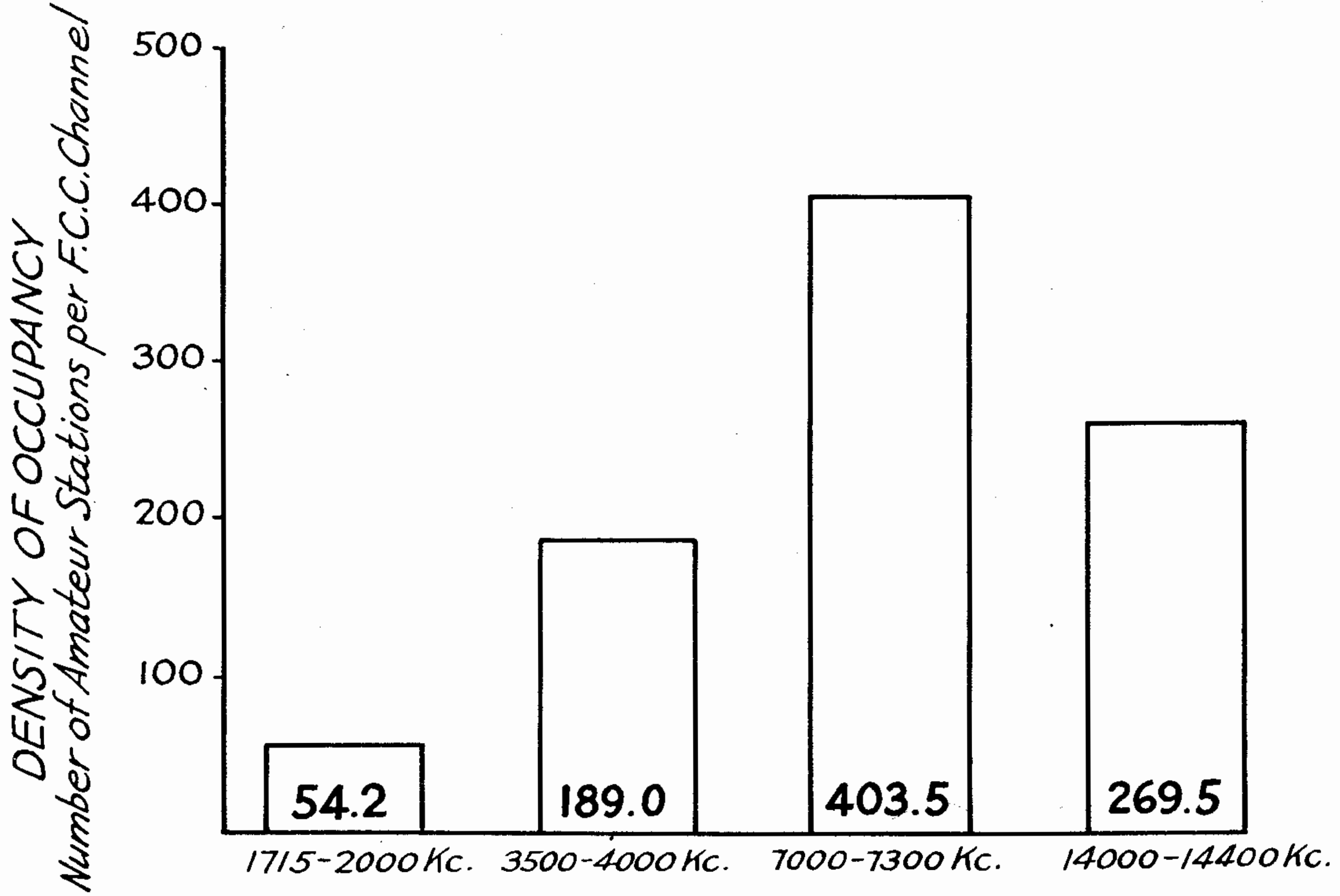
American Radio Relay League - June 1936



F.C.C. CHANNELS REPRESENTED IN THE LOW FREQUENCY AMATEUR BANDS
contrasted to
OCCUPANCY OF THE SAME AMATEUR BANDS

FIG. 3

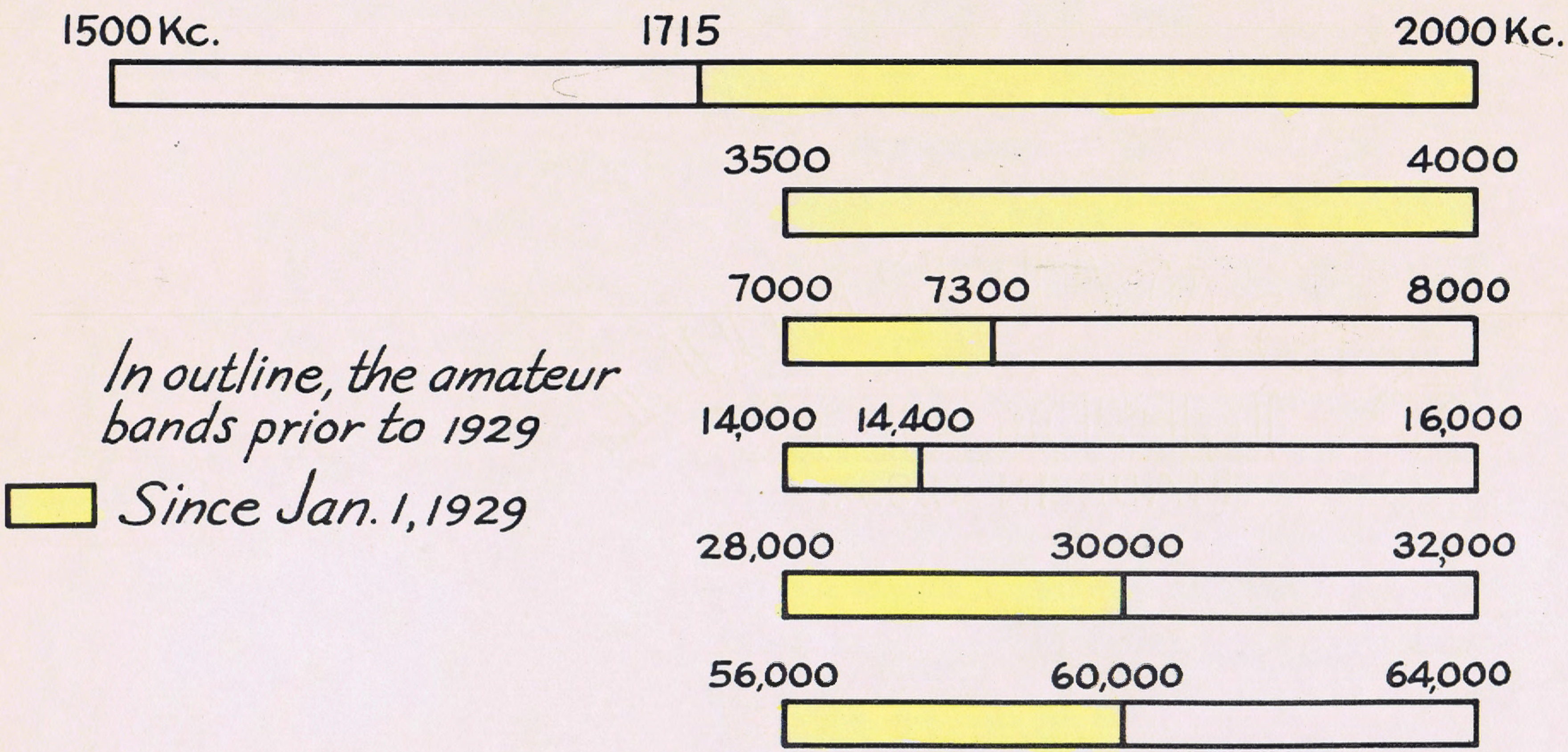
American Radio Relay League
June 1936



OCCUPANCY OF AMATEUR BANDS (Stations per F.C.C. Channel)
WEIGHTED BY INTEGRATED REGISTERED INTEREST BETWEEN BANDS

FIG. 4

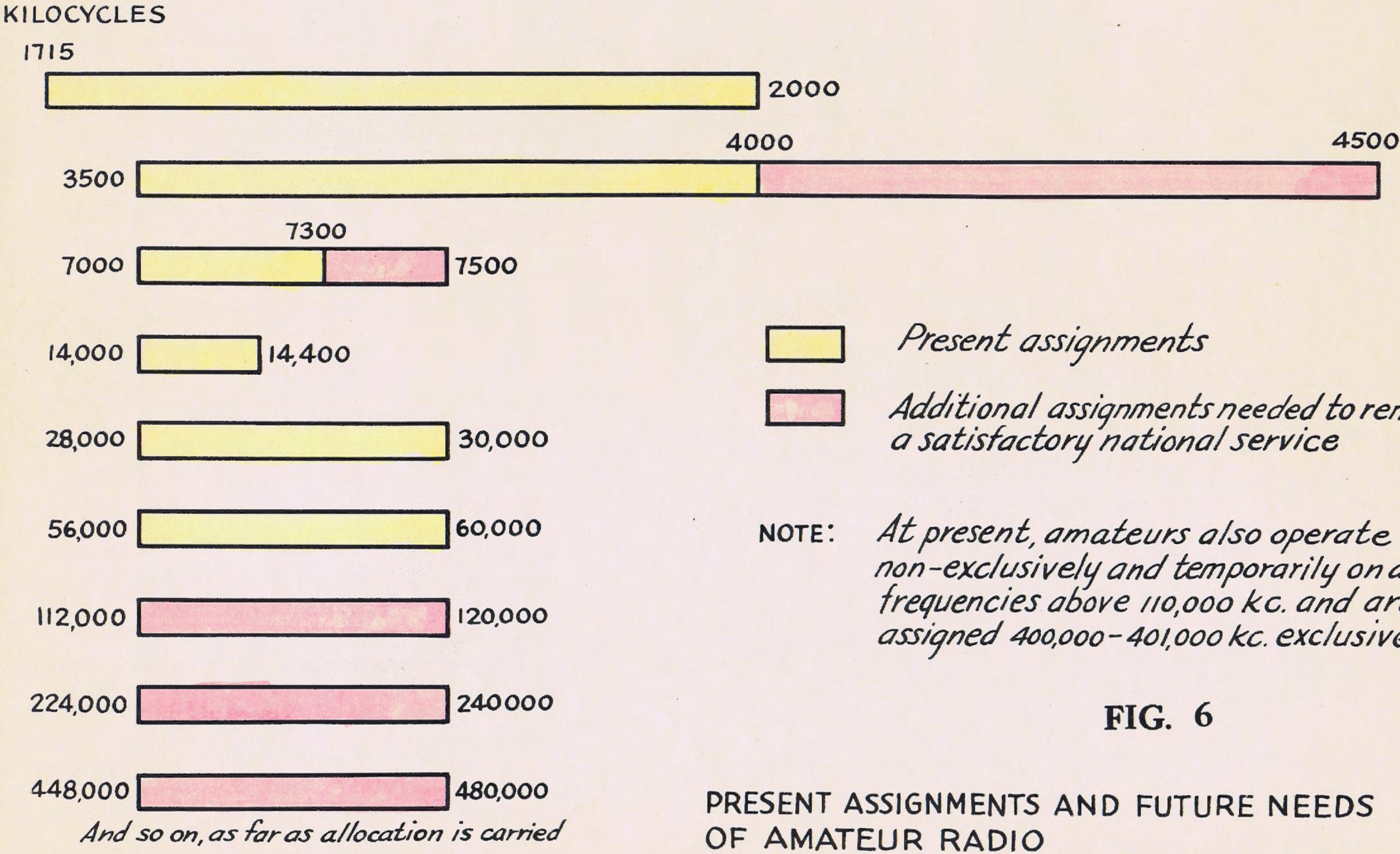
American Radio Relay League
June 1936



THE AMATEUR BANDS BEFORE JANUARY 1, 1929
(Effective date of the International Radiotelegraph Convention of Washington, 1927)

FIG. 5

American Radio Relay League
June 1936



Present assignments

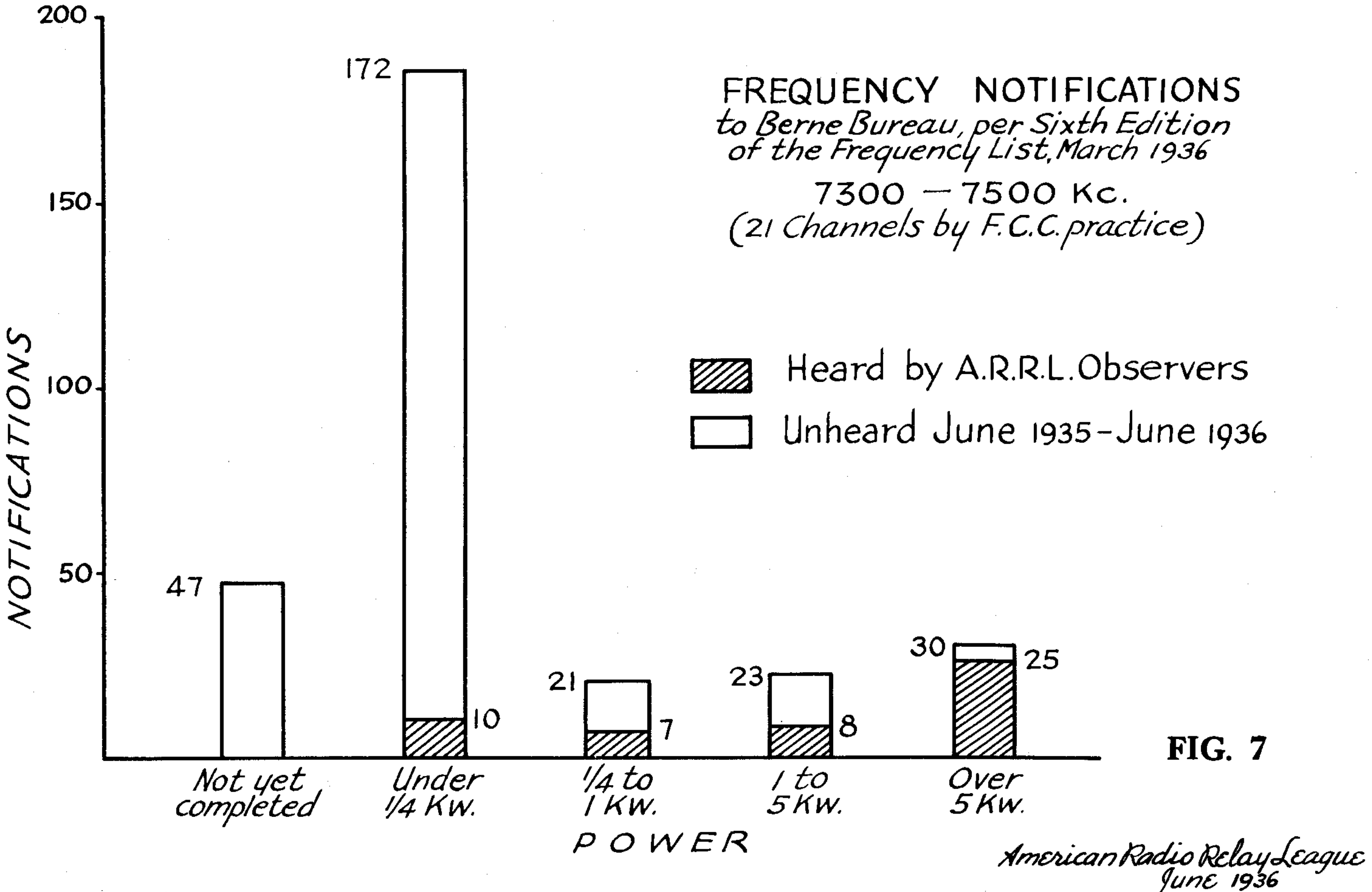
Additional assignments needed to render a satisfactory national service

NOTE: *At present, amateurs also operate non-exclusively and temporarily on all frequencies above 110,000 kc. and are assigned 400,000 - 401,000 kc. exclusively*

FIG. 6

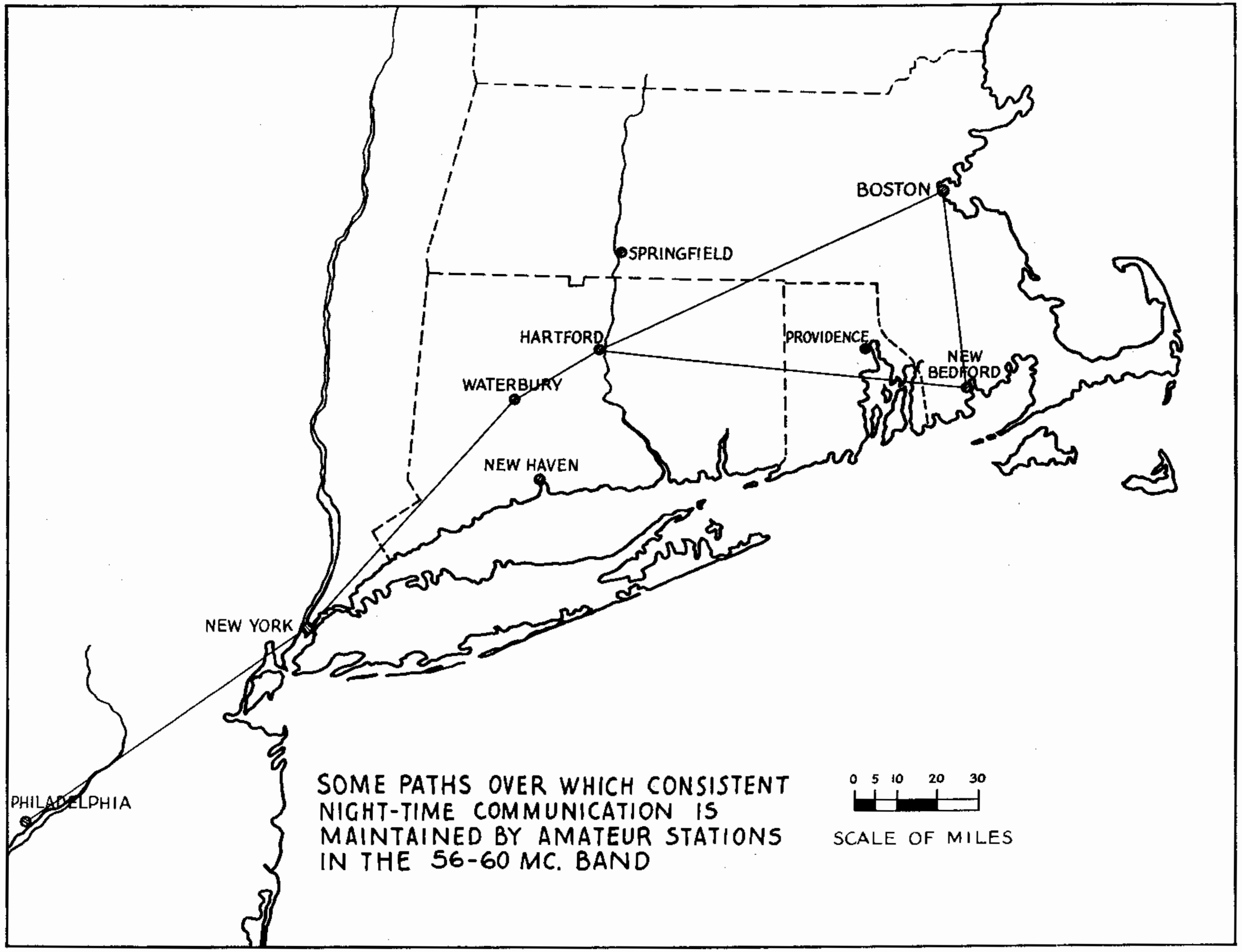
PRESENT ASSIGNMENTS AND FUTURE NEEDS OF AMATEUR RADIO

American Radio Relay League - June - 1936



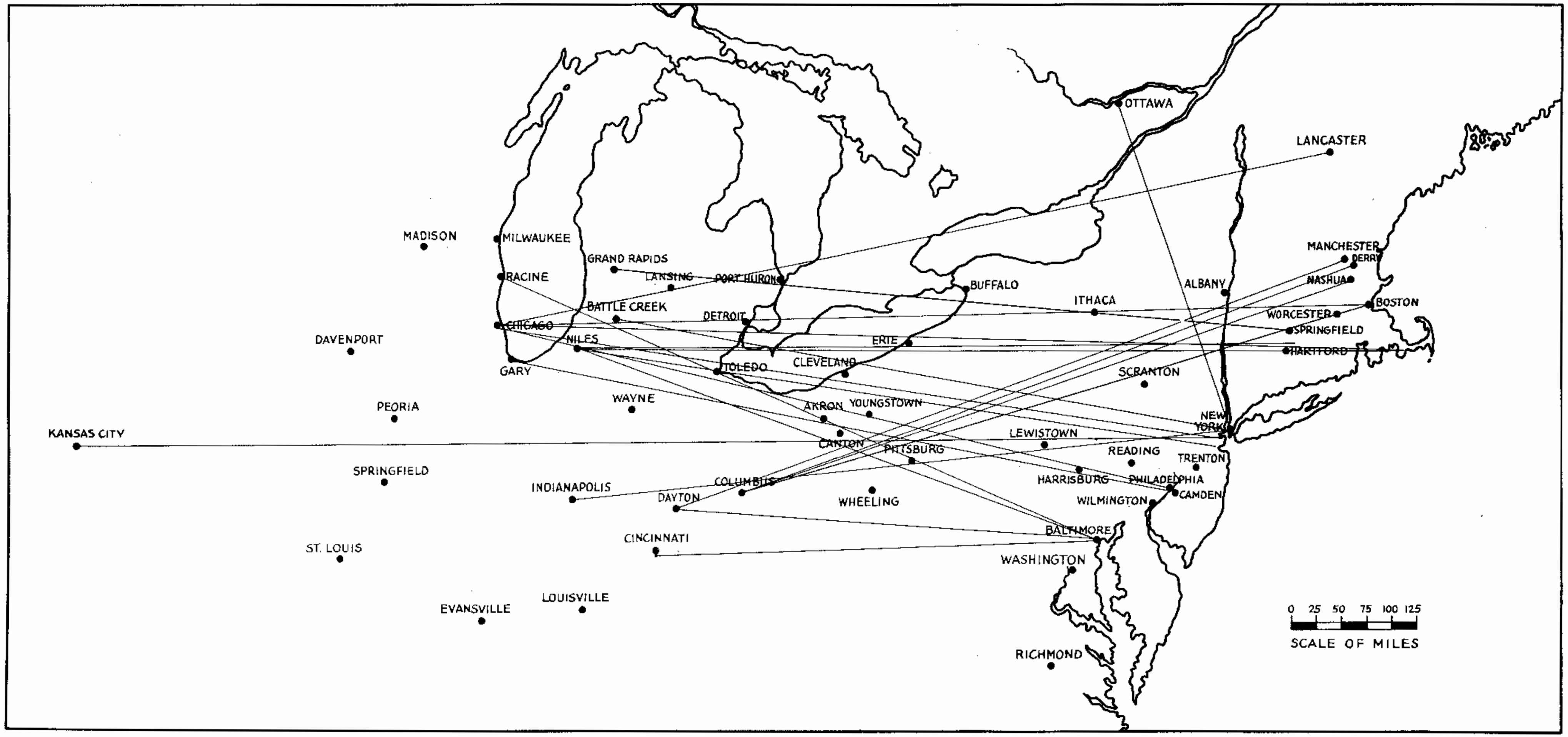
FREQUENCY NOTIFICATIONS
to Berne Bureau, per Sixth Edition of the Frequency List, March 1936
7300 — 7500 Kc.
(21 Channels by F.C.C. practice)
Heard by A.R.R.L. Observers
Unheard June 1935 - June 1936
NOTIFICATIONS
200
150
100
50
47
172
10
21
7
23
8
30
25
Not yet completed
Under 1/4 Kw.
1/4 to 1 Kw.
1 to 5 Kw.
Over 5 Kw.
POWER
American Radio Relay League
June 1936

FIG. 7



American Radio Relay League
June 1936

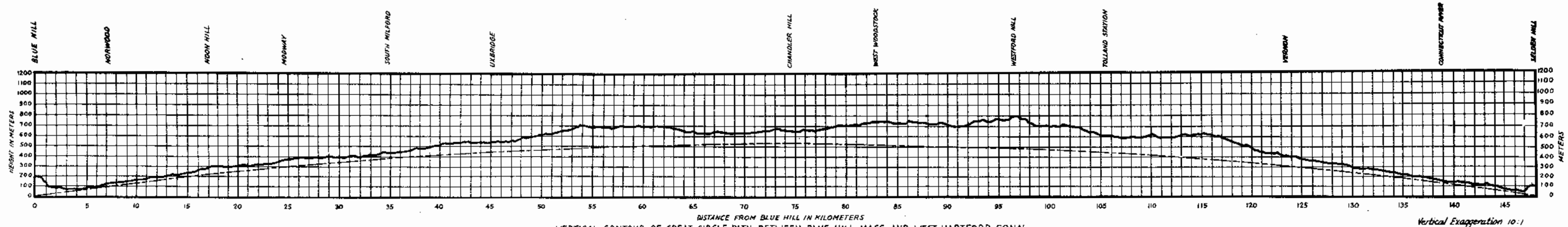
FIG. 8



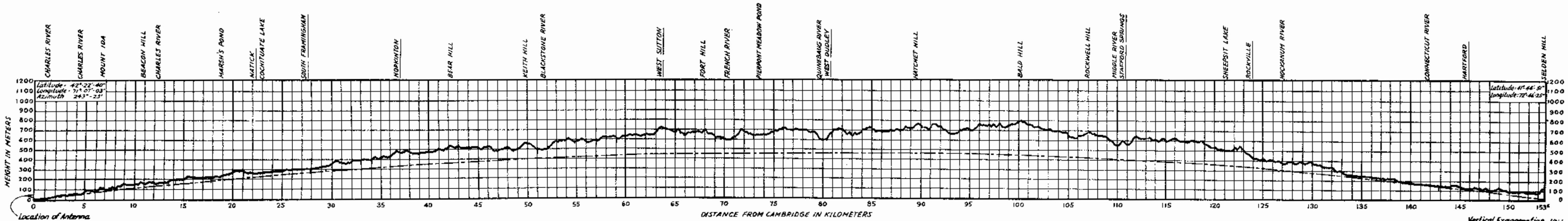
SOME LONG DISTANCE PATHS COVERED BY AMATEUR ULTRA-HIGH-FREQUENCY SIGNALS ON THE 56-60 MC. BAND BETWEEN MAY, 1935 AND MAY, 1936

FIG. 9

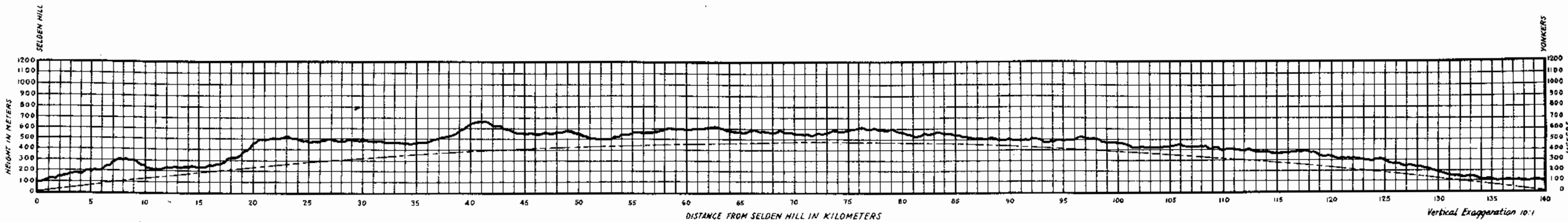
American Radio Relay League June 1936



VERTICAL CONTOUR OF GREAT CIRCLE PATH BETWEEN BLUE HILL, MASS. AND WEST HARTFORD, CONN.



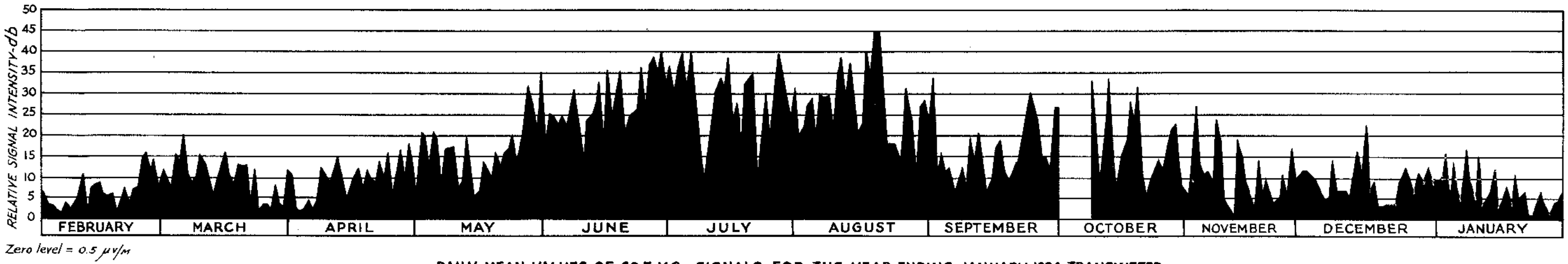
VERTICAL CONTOUR OF GREAT CIRCLE PATH BETWEEN CAMBRIDGE, MASSACHUSETTS AND WEST HARTFORD, CONNECTICUT



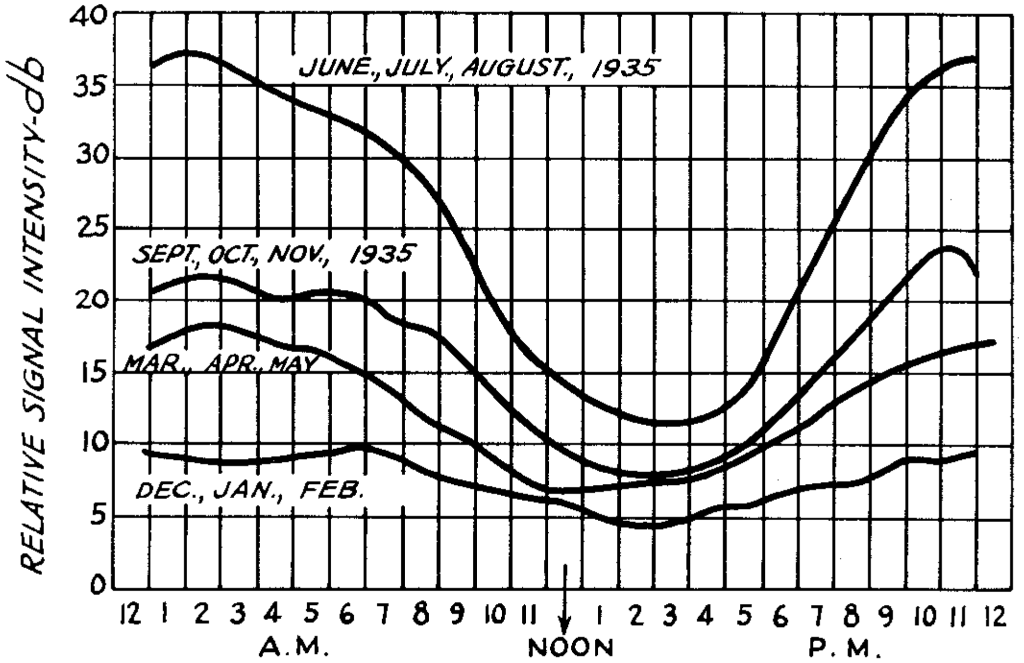
VERTICAL CONTOUR OF GREAT CIRCLE PATH FROM WEST HARTFORD, CONN., TO YONKERS, N. Y.

FIG. 10

American Radio Relay League
June 1936



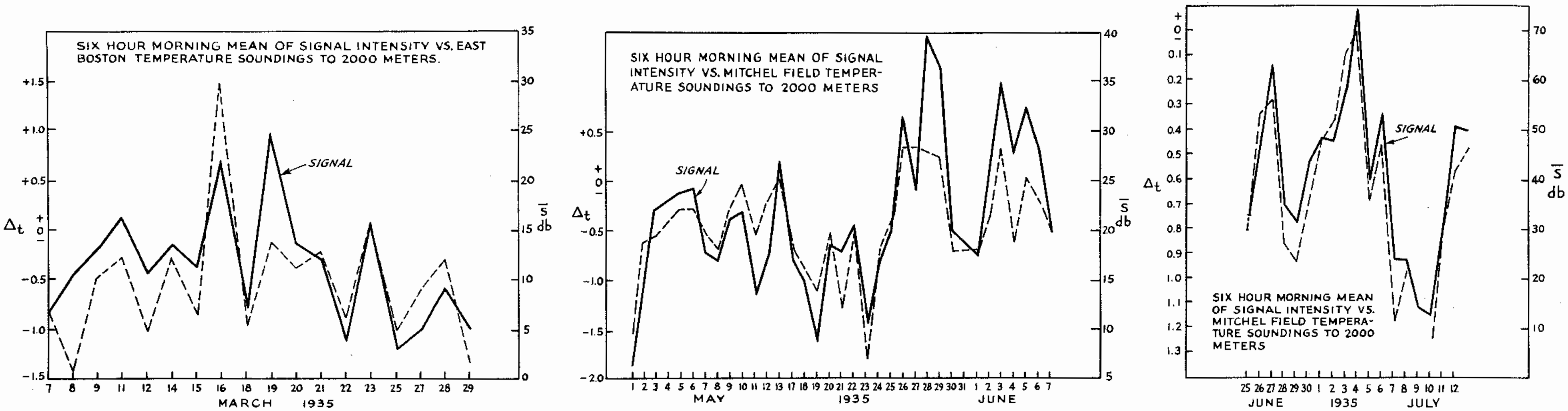
DAILY MEAN VALUES OF 60.5 MC. SIGNALS FOR THE YEAR ENDING JANUARY, 1936 TRANSMITTED FROM THE BLUE HILL OBSERVATORY, MILTON, MASS. AND RECORDED AT WEST HARTFORD, CONN.



MEAN HOURLY SIGNAL INTENSITIES SHOWING CHANGES IN THE DIURNAL CHARACTERISTIC THROUGHOUT THE YEAR

FIG. 11

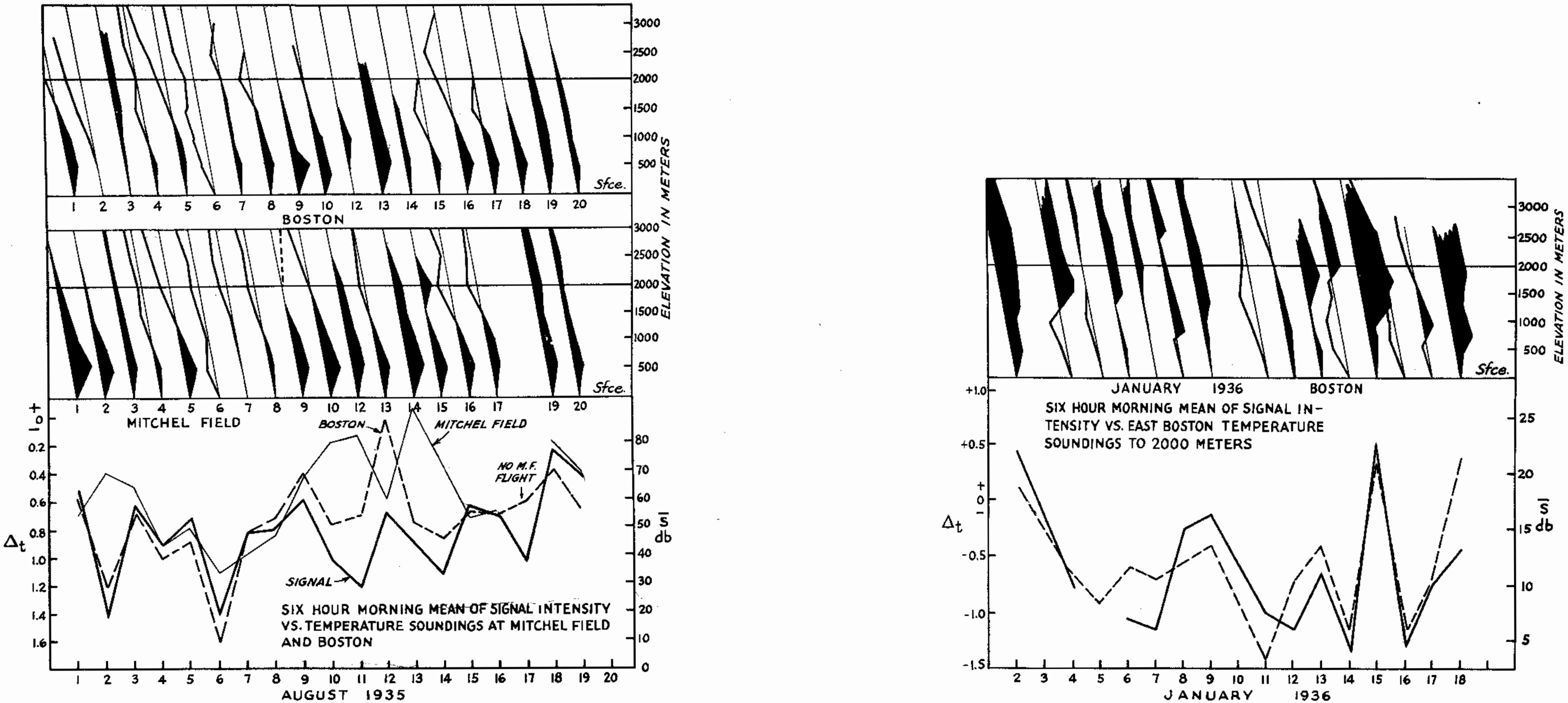
American Radio Relay League
June 1936



STUDIES IN THE RELATIONSHIP BETWEEN VARIATIONS IN THE SIGNAL LEVEL ON 60.5 MC. OVER THE WEST HARTFORD – BLUE HILL PATH AND TEMPERATURE GRADIENTS IN THE LOWER ATMOSPHERE

FIG. 12

American Radio Relay League
June 1936



STUDIES IN THE RELATIONSHIP BETWEEN VARIATIONS IN THE SIGNAL LEVEL ON 60.5 MC. OVER THE WEST HARTFORD–BLUE HILL PATH AND TEMPERATURE GRADIENTS IN THE LOWER ATMOSPHERE

FIG. 13

American Radio Relay League
June 1936